HARMSWORTH POPULAR SCIENCE

EDITED BY ARTHUR MEE

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A STAR'S LIFE-HISTORY

Inferences as to the Development and Decline of Stars Made from Their Differing Appearances

THE MESSAGES BROUGHT TO US BY LIGHT

To the unaided eye, the stars differ in brilliancy and to a certain extent in colour, but they appear on the whole to be very similar to one another. The spectroscope, however, shows that they differ very greatly in constitution, and may be classified into several definite kinds. Thus, we speak of solar stars, of Sirian stars, of helium stars, and of yet other groups which we shall proceed to describe. It must be remembered throughout, however, that these different kinds or classes of stars shade into one another, and that they almost certainly represent different stages through which each star passes in the course of its life-history.

From the moment when the Copernican theory of the universe was generally accepted, the enormous distance at which the stars are situated from us became evident and undeniable. Throughout the whole of the vast journey of our earth's orbit they appear immovable, except in rare cases and to the finest measurements astronomy has yet attained. This immobility implies that they are at such a distance from us that the length of our orbit, from one end to the other, is as nothing in comparison. It is also obvious, therefore, that the light-power of these bodies must be immense, or none of their light could reach us across these immeasurable distances. So it becomes certain that the stars are of the nature of suns, of enormous size and brilliancy.

Nothing, however, of the physical constitution of stars can be learned from telescopic observations. Even the most powerful modern telescopes cannot succeed in magnifying the stars to any perceptible dimensions; they remain, and will remain to the end, mere points of light. Indeed, it is known that, at their least possible distance, a telescope of the power necessary to show them to us with even the slightest disc would be of such dimensions that it could not be set up upon the earth. But the application of spectroscopic analysis has made it possible to decipher in some degree the physical nature of the stars, and much which was formerly conjecture is now certainty.

The stars are indeed suns, enveloped like our own sun with photospheres, or mantles of incandescent clouds, shining with enormous brilliancy. Some of them, generally classified apart as *solar* stars, give a spectrum almost exactly identical with that of our sun, and are therefore, so far as can be ascertained, bodies of precisely similar character. It seems astounding that so much can be known from the mere analysis of the light which we receive from the stars, for this light is in no case more than a single shaft or pencil. But that single pencil of light is collected from the whole semi-circumference of the star, and in its very constitution—as true in this tiny thread as in the broadest beams—brings to us, stamped in characters of light, undeniable indications of the nature of the body from which it comes.

The spectra of the stars reveal to us a vast range of these sun-like bodies, sweeping in practically unbroken gradations, from suns of a size and splendour many times exceeding those of our own luminary, through the ordered harmonies of greater and lesser lights down to bodies which connect the stars in an uninterrupted chain with the nebulæ, and, not impossibly, even with comets.

This sun-like quality, consisting in the presence of a radiating photosphere which constitutes a vast fountain of light, is recognised in a spectrum which is *primarily* unbroken. That is to say, the spectrum consists, not of bright lines or bands here

and there, but of a ribbon passing through the whole range of colours from the red to the violet. The dark lines and bands which are marked upon the background of this continuous spectrum allow us, on the other hand, to distinguish various classes of stars definitely one from another, according to the physical conditions of the star itself, which we are able to learn, in some degree, from this chart. The continuous spectrum shows at once that we have to do with a sun-like body; the dark lines show what kind of sun-like body is before us. For the continuous spectrum comes from the photosphere of the star, and the dark lines and bands are due to the atmosphere which surrounds that photosphere.

Stars that Seem to Have the Same Composition as Our Sun

Typical solar stars, which form a large proportion, though by no means the majority, of all the stars that have so far come under observation, give a spectrum in every respect similar to that of our sun. The continuous spectrum of the photosphere is crossed by innumerable fine dark lines, produced by metallic absorption in the cooler atmosphere above. The traces of hydrogen are slight in this class of stars; only four hydrogen lines are visible in stars of true solar type. Where, as is sometimes the case, more than four hydrogen lines are present, it may not improbably turn out that the reason is to be found in the existence of a companion star—that is to say that the spectrum is really that of a double star. This has recently been proved to be the case in Capella, for long regarded as a model solar star, but in whose spectrum extra hydrogen lines appeared in the violet. These lines are now known to belong to a companion of the Sirian type. In solar stars, as in the sun itself, the lines of calcium are very marked; they are two broad lines in the blue and violet, very prominent in the solar spectrum.

The Enormous Differences in Size Between the Sun-like Stars

It is practically certain that the constitution of these solar stars is identical with that of the sun, and that they would reveal, if closer examination were possible, a similar array of magnificent appendages, such as sunspots, faculæ, prominences, and corona. Stars of this type vary enormously in size, Canopus, perhaps the largest, being estimated as nearly six million times the mass of our sun, while one of the most insignificant, a star in the constellation of the Great Bear known as "Groombridge 1618," is of so small a mass that it would take three hundred and fifty of him to make up the sun; yet both are true solar bodies, and between them are others of all sizes.

This wide difference in size means a wide difference also in the value of the force of gravity in each; yet the identity of their spectra seems to prove that not only are the proportions of chemical elements the same in all, but also the conditions of temperature and of pressure must be the same, though these conditions are, of course, considerably affected by gravity. The explanation probably is that there is a constant ratio of forces in these bodies; and the late Miss Agnes Clerke suggested that "we might even venture tentatively to define solar stars as bodies in which the ratio is the same between gravity and electrical repulsion."

One of the most remarkable features of stars of this class is that they remain in very large numbers unalterably true to type, their spectra showing so closely alike that they can hardly be distinguished. This seems to indicate a particularly permanent condition of existence, and may perhaps be taken to imply a long life, without any considerable change, for our own sun.

The Sirian Stars that Shine Dazzlingly Through an Atmosphere of Hydrogen

These solar stars are generally of a somewhat golden tinge. The enveloping vapours that intercept much of the photospheric light in bodies like our sun produce a mellowing and softening of its quality, otherwise it would come to us in a dazzling blue brilliancy. Such is, in fact, the nature of the light we receive from another class of stars, more numerous even than the solar stars, and probably comprising one-half or more of all that are known.

These are called *Sirian* stars, after Sirius, the Dog Star, which is the most famous example of their type. They are of a radiant white or blue colour, and show a spectrum remarkably free from dark lines such as are found in immense numbers throughout the length of the solar spectrum, and are due to metallic absorption. The lines of hydrogen, however, which are but faintly marked in the spectrum of the sun, are peculiarly dark, broad, and complete, the whole series being present in every typical star of this class. This signifies that Sirian stars are surrounded by an atmosphere consisting principally of hydrogen.

The brilliancy of these stars in proportion to their estimated mass, in the few cases

where such estimation has been possible, is remarkable. Sirius presents peculiar advantages for the purpose of such comparisons. It has been more closely observed than almost any other star, and it is also one of those nearest to our earth. It is at a distance from us which it would take light somewhat less than nine years to travel. This is a very short distance compared with the hundreds of light-years at which many stars are placed from us. Sirius has a dark companion, and it has been possible to find the character of their mutual revolutions, and from these, combined with the parallax, to compute the mass of Sirius. This is found to be two and a half times the mass of the sun, so that it might be expected to give a light not quite twice as great. The actual brilliancy of Sirius, however, is twenty-one times that of the sun—that is to say, the ratio of light to mass is in Sirius eleven times greater than it is in the sun.

The method by which the brilliancy of the two luminaries has been compared is interesting. As it would be impossible to secure any really reliable result by direct comparison of lights received in such enormously different quantities, a comparison star of solar type was chosen, the spectrum of which corresponds exactly with that of the sun, and which has been discovered to be of equal mass also.

The Measurement of the Blaze of Sirius Compared with Our Sun's Light

This solar star, in the constellation of Centaur, was compared with Sirius with regard to brilliancy of light, and the results were assumed, with a reasonable amount of certainty, to be applicable to the comparison of Sirius with our sun.

The spectroscopic analysis of their light affords us the means of accounting with considerable probability for some part, at least, of this luminous superiority in Sirian stars. The Sirian spectrum is, as we have seen, peculiarly deficient in dark lines showing metallic absorption, which implies that these stars are not surrounded by an envelope of metallic vapours, such as encircles the sun and absorbs a large proportion of the light from his photosphere. They are surrounded, on the contrary, by an envelope consisting almost exclusively of hydrogen, and therefore more transparent. It seems certain that a very large proportion of the light produced by Sirius is radiated directly through space, and that we receive his brilliancy very nearly undimmed. In the case of the sun, however, something like one-third of the original light is lost to us by self-absorption.

There may also be other contributory reasons for the excess of luminosity. For example, it is probable that Sirius and stars of his order are of a density much less than that of the sun, so that they have photospheres much larger in proportion to their mass. This is, so far, only a hypothesis; but the absence of any considerable loss of light through absorption by enveloping vapours is an established fact which may be read recorded with undeniable clearness in the spectrum.

Intermediate Grading of Stars Between Type and Type

Between the two definite types of Sirian and solar stars is an uninterrupted series of gradation-types combining in different proportions the characteristics of the two, Thus, as the hydrogen lines, dark, broad. and complete in the Sirian stars, become fainter and thinner, and as the series becomes less completely marked, the numerous delicate rulings of the solar spectrum begin to appear and assume gradually more and more predominance until we get the true solar type. In some intermediate examples the characteristics of both appear clearly marked and quite evenly balanced, so that it is a difficult matter to classify these stars. In the case of one star, Procyon, in the constellation of the Lesser Dog, Professor Pickering was led by this remarkably even balance of the two types, and the clearness of the lines of both, to conclude that the spectrum might in fact be the result of two stars in exceedingly close conjunction, one of them being a Sirian and the other a solar star. This is, of course, possible, but the more generally accepted opinion is that the spectrum is that of a single star, combining the features of the two types in remarkable equipoise and completeness.

The Helium Stars Emerging Out of Nebular Surroundings

Within the last ten years a special set of stars, which had been usually classed among the Sirians, emerged into importance as a class apart, and representing a stage still further removed from solar stars than are the ordinary Sirian or hydrogen stars. These stars show, of course, like all others, the continuous spectrum, but it bears in this case almost no markings superimposed upon it. The spectrum is almost blank. But the hydrogen lines can be just made out, and, what is of chief importance, and gives their name to this group of stars,

there are well-marked signs of helium. These helium lines have already become effaced in true Sirian stars, and the dark, bold hydrogen lines have become predominant instead.

Helium stars are of great interest and importance, for they have been found to have close analogies with gaseous nebulæ, and in some cases they appear to have nebulous appendages still attached to them. They are fairly numerous and are found in most parts of the sky, but by far the majority of them are situated in the region of the Milky Way. The constellation of Orion is especially rich in helium stars, so much so that they are sometimes called Orion stars. They have been proved to be of very low density, and their light comes to us from the photosphere with even less loss by absorption than that of Sirian stars.

The Great Helium Stars that Twinkle at Us Out of Orion

Practically all the light which is produced is radiated into space, and these stars are consequently all pure white in colour.

Bellatrix, in Orion, is a good example of a helium star. It has the bluish-white tinge significant of light which has suffered no substantial alteration from the action of intervening vapours; all the portions of its light have the intensity proper to them. Rigel, a first-magnitude star at the foot of Orion, is a helium star in which other lines have begun to show themselves; the hydrogen lines are becoming strongly developed in this star, though not yet of the width and intensity of these lines in typical Sirian stars. When hydrogen attains the predominance which it has in Sirian stars, helium is no longer to be perceived; it can apparently hardly imprint itself except when practically in sole possession of the field.

The chief interest of helium stars lies, as we have said, in their evident nebular relations. These have been of considerable importance in the building up of a theory of stellar evolution.

Why Some Stars Shine with a Clearer Light than Others

The light of Sirian stars, and still more of helium stars, comes to us, then, very much more directly than solar light and in much greater native purity. It is more violet in tone and of an intense flashing brilliancy. It has been suggested that this absence of surrounding atmosphere is due to a condition of much greater heat in the Sirian and helium stars; but this theory seems hardly tenable, for it is surely probable that increased heat would intensify the process of metallic vaporisation, and so produce a more complex enveloping atmosphere, and increase rather than diminish the absorption of light. A more satisfactory explanation regards the absence of metallic vapours as due to the greater effective force of gravity in Sirian than in solar stars. It is assumed that in the sun, and in other stars of the same type, the effect of gravity is to some extent counteracted by the force of electrical repulsion—that is to say, the substances forming the sun's gaseous envelope, which would otherwise be drawn inwards behind the photosphere by gravity, are kept in their position surrounding it by the action of some electrical repulsive force. This force, whatever it may be, is presumably much less powerful in stars of the Sirian type, so that all the heavier metallic vapours, which in the sun go to form its outer envelope, are in these stars drawn in by the gravitational action of their own weight, some few of the lighter vapours conceivably remaining just above the photosphere, but hydrogen alone being sufficiently light to retain a position at all corresponding to that of the gaseous envelope of the sun. It is just possible, therefore, that our sun might assume the character of the Sirian stars by a gradual diminution of this electrical repulsive force, in which case its light would no longer be warmly red and mellow, but a cold, glittering blue or violet.

The Different Effects of the Absorbent Power of Vapours

Certain stars, usually classed as belonging to the solar type, because they conform on the whole to the spectrum of our sun, show, however, in some degree the characteristics of a very interesting class, varying from our sun in the direction contrary to that in which the Sirian stars vary from it. They bear signs of a greatly *increased* absorbent envelope of vapours, the spectrum showing almost complete absorption of the more refrangible or violet rays, while throughout there is a deepening of the lines which indicate metallic absorption. Aldebaran, the chief star in the constellation Taurus, is the most striking example of this transition stage. It is of a decidedly red colour, and of tremendous light-power. In spite of the amount of self-absorption which its light suffers, it is of the first magnitude, and its brightness is estimated at not less than twenty-eight times that of the sun, and probably more. Its spectrum shows the lines of metals with high vapour-densities, which are absent, or nearly so, from the

spectrum of the sun. It is clear that the enveloping vapours of this star are not only more extensive, but are also of a more complex and more absorbent kind. The violet rays hardly succeed in getting through at all, and it was only with the utmost difficulty that any impression of them has ever been obtained. More significant, and significant in the same direction, are the traces of incipient "flutings" which may be distinguished in the spectrum of this star, for they connect it with the following classes.

A small proportion of the stars so far observed show clearly in their spectra the bands which are described as flutings. These bands are of two distinct kinds, separating the stars in whose spectra they appear into two sharply divided classes, with none of those gradations between them which usually diffuse the boundaries of marked physical differences. In the first case, the bands are sharply defined towards the violet end, but shade off gradually towards the red. They occupy identical positions in all members of this class; the type is so far absolutely fixed. The stars vary, however, in the intensity with which they show the bands, and also in the relative importance of the various bands in the spectrum. This band-spectrum is, as it were, superimposed upon a spectrum of the solar type; it represents, therefore, a stoppage of light which takes place at a further distance from the photosphere and consequently in gases of a lower temperature.

The Progress of Knowledge Respecting the Chemical Meanings of Starlight

It is thought that these bands are produced by chemical compounds as distinguished from chemical elements. Yet no satisfactory explanation of them could for long be suggested. All that could confidently be said of these stars was that they are surrounded by a much deeper and more complex envelope of vapours, at different stages of temperature, and that consequently their light is subject to very greatly increased absorption. The bands register, in fact, a new kind of light-stoppage. It was also seen that the bands themselves are made up of a great number of individual lines arranged in rhythmical series corresponding to the known series of the hydrogen lines, but pressed closely together; each band represents, so to speak, a condensed but rhythmical series of lines. But quite recently a beginning has been made in penetrating the chemical meaning of these bands.

In 1904 it occurred to Mr. Fowler to compare the flutings of these stars, which are often called *Antarian* stars, after a prominent example of the type, with the flutings produced by titanium oxide when rendered luminous by the application of electricity at low tension. The result was a great discovery. The flutings of titanium oxide agreed with remarkable closeness with eight out of the ten bands of the Antarian spectrum; and this agreement was found to extend to the arrangement of the lines which make up the flutings. A great step forward has thus been achieved. It is at least fairly certain that titanium oxide is largely responsible for Antarian flutings. Another point of considerable interest is the discovery in this spectrum of flutings due to cyanogen, for until quite recently no traces of carbon had been discovered in Antarian star spectra.

The Great Red Antarian Stars with Their Signs of Titanium Oxide

These stars are all of a red or reddish colour, and many of them are what are called *variables*—that is to say, they are subject to fluctuations in brilliancy ranging in some cases over several magnitudes.

A beautiful star of this class is Betelgeux, the brightest star of Orion. Its banded spectrum is clear, but faint enough to allow the line spectrum below to be distinctly seen. Betelgeux is of a deep red colour, and, in spite of the amount of light lost by absorption, is of the first magnitude. In the brightest star of the constellation Hercules, the intensity of the bands has deepened so considerably that the intervening parts of the spectrum are thrown into vivid contrast, and appear as bands of brilliant light—so powerful, indeed, that some observers have concluded that bright lines are present in the spectra of this and similar stars; this, however, is very unlikely, though it may be the case. Another first magnitude star of this class is Antares—the chief star of the constellation of the Scorpion—which gives its name to the class.

Stars that Vary Their Light Through the Thinning of Their Atmospheric Vapours

All stars so far known which have banded spectra are at a very great distance from us, and are of extreme immobility. Yet we find among them stars which, even at inconceivably enormous distance, and after suffering very great loss of light by absorption, still come to us with a brilliance of the first magnitude. Their intrinsic brightness must therefore be extraordinarily immense. It is estimated that the photosphere of Antares must be at least eight hundred

times that of the sun in extent, and its mass is probably more than twenty-two thousand times as great as his. Betelgeux is, if anything, more powerful and more distant even than Antares; these figures would therefore be considerably exceeded in his case.

Another wonderfully beautiful star of this class is Mira (the "wonderful") Ceti, a variable star of a glowing red colour, in which, however, the radiating function is already considerably decreased, and the absorption by surrounding vapours is very great, as reflected in the deep shading of the bands in its spectrum. It has been discovered that the fluctuations in brightness are caused by the movements of the surrounding layers of light-stopping atmosphere, which at one time close in thickly and at another thin off. When the star reaches its most brilliant phase, several substances, but in a supreme degree hydrogen, are kindled into vivid rays, in a manner suggesting the action of magnetism.

Stars that are Farthest Removed from the Sun in Their Composition

About fifteen per cent. of Antarian stars are known to be variables, and most of the remainder appear to show symptoms of some degree of instability. The more variable the star, the further it would seem, according to its spectrum, to be removed, in constitution, from the sun. About eight hundred stars of this type are known up to the present. They lie more or less isolated, and do not collect into groups in special parts of the heavens.

The other type of stars with banded spectra, called *carbon* stars, are, however, found for the most part grouped together in special localities in the heavens, particularly in the Milky Way. The bands in the spectra of carbon stars are shaded in the reverse direction from those of Antarian stars—that is to say, they are sharply defined towards the red and shade off towards the violet. There are only three of these bands, but their great interest consists in the fact that they are found to lie in exactly the position of the three *light* bands which have been looked for, so far in vain, in the spectra of comets.

Carbon Stars Beyond the Reach of Natural Human Sight

There is no doubt that these bands are due to carbon, and, it is conjectured, to carbon in some form of combination with hydrogen, for the same absence of hydrogen lines has marked their spectra as has marked the spectra of comets. It is believed that the only way of accounting for the lack of any sign of this most universal of substances is to consider that it is all used up in the formation of hydrocarbons. Additional weight is lent to this theory by the fact that these three bands are exactly in the position of the three bright bands produced by burning alcohol and other hydrocarbon substances. Traces of cyanogen have quite recently been discovered in the spectra of carbon stars. The only other elements so far identified are sodium and iron, and it is interesting that these two metals, and no others, have once or twice been traced in the spectra of comets. The important discovery has recently been made that *bright* lines in large numbers are interspersed among the dark lines of some of these star spectra.

In these bright lines—which are always due to the shining and not to the absorptive power of gases—we seem to trace affinities between carbon stars and gaseous stars and nebulæ. The dark lines of their spectra, however, seem to show that they are more nearly related to solar than to Sirian stars, for their dark-line spectrum is very like the solar spectrum. Another sign of this relationship may be found in the fact that their light is blurred and fitful, and of a red colour, all of which conditions point to a further development of the vapours which surround solar stars. Only about one hundred and twenty carbon stars are known, and all of these, with the exception of eight, are visible only by the telescope.

Does the Appearance of the Stars Tell an Evolutionary Story?

They are at unimaginably great distances from the earth, but the faintness of their light is chiefly due to the enormously thick curtain of vapours in which they are enveloped, so that it is only when this curtain is rent or attenuated that rays of light can succeed in making their way through in any considerable strength. The violet rays, being most refrangible, are cut off entirely, or, if they get through at all, are exceedingly faint. The colour of the light is therefore usually deeply red. But it now appears that there are some exceptions to this rule, for two stars have been discovered giving spectra of this class, but continued well into the blue, and themselves white in colour. Carbon stars are sharply distinguished from the first-named class of stars with banded spectra—namely, the Antarian stars. No combination of the two kinds of spectra is ever found; there are no gradation-types between them.

There are good grounds for believing that

these various classes of stars represent different stages of stellar evolution—that is to say that, in the gradually merging types, we have exhibited the successive stages of a star's development. The completeness of the progressive series and the unmistakable affinities between them strongly support such a view. One fact, however, seems against it—namely, the tendency by which the stars group themselves in space according to their kind. Certain kinds are practically restricted to certain portions of the sky. The significance of this distribution is not, however, by any means clear; it is possibly capable of an interpretation not inconsistent with the evolutionary theory.

The Great Cycle of Stellar Life Through Helium, Sirian, and Solar Periods

The facts that helium stars are in some cases not detached from nebulæ, and that they are of very low density, are direct evidence of comparatively recent emergence from the nebulous state; it seems quite clear that they must be the youngest of the stars. That once assumed, the succession through Sirian and solar types is absolutely unbroken, so that no definite boundary line can be drawn where helium stars end and Sirian stars begin, or where Sirian stars end and solar stars begin. There is, therefore, a strong presumption that our sun, in progressing from the nebulous state to that in which we know it, had to pass through all the stages represented respectively by these types of stars, and by all the gradations between them. The classes of stars we have been considering may, then, with considerable probability, be taken to represent the progressive development of a star's existence somewhat as follows.

In the earlier stages of its condensation from the nebulous matrix, the star is practically free from surrounding atmosphere, and is of very low density. Its light-producing surface is very large in proportion to its mass, and the light itself reaches outer space without any sensible modification, and preserving the blue tinge proper to photospheric light.

The Rise and Fall of the Temperature of Suns Through Unnumbered Years

With the gradual wasting of heat by radiation, gravity gains increasing power, and the body slowly condenses.

Although there is this continual wasting of heat, there is for a very long time no loss of temperature; indeed, there is a constant rise of temperature. This is because condensation renews the supply of internal heat more quickly than radiation reduces it, the motion of particles falling towards the centre being transformed into heat when it is arrested. Thus, the process of condensation may go on for ages attended by a rising temperature, until it reaches a maximum; it is only then that the constant giving out of heat begins to tell upon the body itself, and it cools slowly down to extinction.

Such is, at least, the conjectural course of a star's life as far as we can interpret the physical differences of stars. We do not, indeed, know what other forces may be at work to interrupt the action of the laws of heat and gravity as known to us, or to produce some unforeseen restoration of energy. Another difficulty also occurs. The process of condensation proceeds in due order through helium, Sirian, and solar stars, with increasing modification of light through the thickening vapours surrounding them. But, although there is no perceptible break between solar and Antarian stars, the process appears to be no longer identical, for the density of Antarian stars is notably lower than that of the sun, and, in general, they appear to be much more nearly related to nebulæ. Yet they follow, as in a series of inevitable evolutionary changes, the phase of existence typified in our own sun, although they seem to represent a phase well advanced in deterioration and proceeding to decay.

The Carbon Star which Cannot yet be Placed in the Evolutionary Series

It does not seem extravagant to regard them as a series of steps upon an inclined plane leading to the utter extinction of the star's light, and plunging it among the unknown hosts of dark bodies which pursue their courses in space, unseen and undiscoverable except in a few cases here and there, where they are recognised by their action on one or other of the luminaries.

The place of carbon stars is not easy to conjecture. The only suggestion which has been made is a plausible theory of Professor Vogel, who regards them as collateral with Antarian stars, but representing an alternative way of descent from the solar form towards extinction. They are subject to the same light-fluctuations, and their spectra, though definitely independent, show absorption produced in atmosphere which must be in some way similar. The theory is a possible one, but there are important features of carbon stars unaccounted for by it. It is therefore best, at present, to allow carbon stars to remain apart and to regard them as of unexplained genealogy and life-history.

A WISTFUL BREAK ON OCEAN'S SOLITUDE

PALM TREES GROWING ON THE SEASHORE OF THE WONDERFUL ISLAND OF CEYLON

THE ISLANDS OF THE MAIN

In What Way Did the Sterile Islands of the Loneliest Seas Become Fertile and Inhabited ?

HOW WERE THE PACIFIC ISLANDS FORMED?

ISLANDS are usually divided into two classes—continental islands and oceanic islands. Continental islands are islands that have formerly been joined to continents, while oceanic islands are islands that spring from the bottom of the ocean, and have always been insular, isolated, and self-contained. England, Sardinia, Corsica, Nova Zembla are continental islands, for they were formerly continuous with the continent of Europe. Madagascar is a continental island, for it was formerly continuous with the continent of Africa. Ceylon is a continental island, for it was formerly attached to the continent of Asia. Tasmania is a continental island, for it was formerly part of the continent of Australia. On the other hand, the Sandwich Islands, the Maldives, the Aleutian Islands, St. Paul, St. Helena are oceanic islands; they rise from the deep sea, and have never been attached to any continent. New Caledonia and New Zealand are continental islands of a special type, in that the continental masses of which they once were part have subsided below the sea.

The largest continental islands are New Guinea, 306,000 square miles; Borneo, 286,000 square miles; Madagascar, 230,000 square miles; and Sumatra, 130,000 square miles. In some cases there is only a shallow channel of recent origin between continent and island. Between England and Europe, for instance, there is only a shallow channel of quite recent origin; and a fall of the sea-level or a rise of the land-level of a few hundred feet would wed again continent to island. In other cases, as between Madagascar and Africa, there is a deep channel of very ancient origin. But it matters not how deep, or wide, or old the severance between continent and island may be, in all cases, if the island was at any time part of a continent, it must be considered a continental island. The larger continental islands usually give origin to other smaller islands. England has its Isle of Man, and Isle of Wight, and Anglesea; Scotland has its group of western islands, and these have been severed from their parents in much the same way as their parents have been severed from the original continent—that is to say, by movements of the land, and by corrosion of rain and rivers.

A few islands may be distinguished as "coast" islands. These are neither detached from continents nor do they rise from deep ocean, but consist of mud heaped up in the sea near the coast by the agency of large rivers, or by the action of breakers. At the mouth of the Mississippi many such islands are to be seen, made of the mud brought down to the sea by that mighty river.

Oceanic islands naturally group themselves into two classes: (1) volcanic islands which have been built up from the bottom of the sea by volcanic agencies; (2) coral islands, built mainly by the coral polyps on submarine ridges or submerged peaks in the deep ocean.

The coral islands are found only in warm seas; they are most plentiful in the Western Pacific, the western Indian Ocean, and the Gulf of Mexico. The volcanic islands are found widely dispersed, but always in regions of volcanic activity. Often, as in the case of the Aleutian Islands, the Kuriles, and Philippines, they occur in chains, but in other cases they occur singly. The Marianne and Galapagos Islands have several active volcanoes, and more than two thousand inactive cones. The Fiji Islands, the Friendly Islands, the New Hebrides, the Sandwich Islands, the Sunda Islands, and hundreds of others are of volcanic origin.

Since the oceanic islands were never connected with continents, their flora and

fauna must have been imported. Only birds could reach them, and such animals and seeds as might drift to them on logs and other driftwood. Accordingly, both their fauna and flora are rather restricted.

Though the least important, the most interesting of all islands are the coral islands, for their mode of origin and their setting in the azure Southern seas both make a great appeal to the imagination. Let us therefore look for a moment at the manner of the making of coral islands.

We have already noticed how chalk and limestone have been built up of the shells of foraminiferæ, which in the first place accumulated on the ocean floor. Many other shells go to the making of limestone rocks. The oyster-shell beds which are found as regular banks in certain parts of the sea, the accumulations of the shells of sea-urchins and stalked starfishes, the coralline algæ—in fact, the limy remains of all animals with the power of extracting lime from sea-water, are material for future mud. But of all the lime-builders that make limy rocks, none are more active and more effectual than the coral polyps which build mountains and islands and ramparts of lime up from the bottom of the sea.

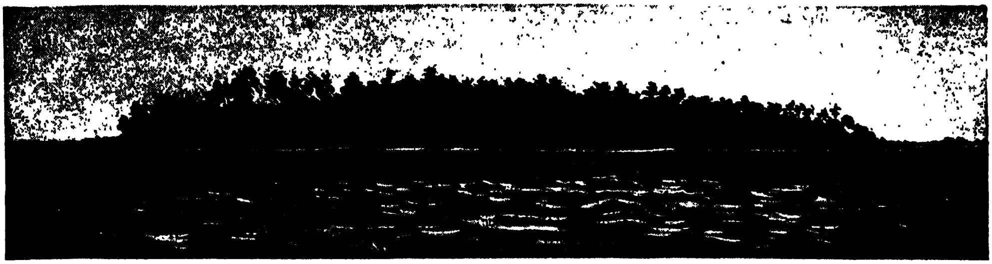
A ROCK FLUNG UP OFF NEW BRITAIN BY A VOLCANIC DISTURBANCE

The coral polyps are cousins of the sea-anemone. They all have little, bag-like bodies, not unlike in shape one of the safety ink-bottles, and they have a circle or circles of little arms or tentacles round their mouths just like sea-anemones, but they differ from sea-anemones in that they extract carbonate of lime from the sea water, and form a kind of cup-like skeleton which remains behind after death and dissolution of the animal. This limy skeleton is known as coral.

There are many species of coral polyps, such as astræa, porites, madrepora, millepora, and each has its own characteristic skeleton. In some cases the coral polyp bears young polyps as buds, and these in turn bud, so that eventually there is a branched structure of coherent polyps, and the skeleton that results is the branched coral which is so familiar. In other cases a similar budding takes place, but the buds are all compacted together, and the resultant skeleton takes the shape which, on account of its finely convolved appearance, is known as "brain-coral." Of the branched skeletons of coral polyps, coral reefs and coral islands are mainly made. But it must not be supposed that a coral island is merely a charnel heap of skeletons, a whited sepulchre. Above low water it is dead, beneath thirty-fathom line it is dead, but sandwiched between the skeletons there is a colony of millions and millions of delicate living creatures—a "submarine flower garden" of living, moving, multiplying anemones, each with its circlet of subtle and sensitive tentacles.

We find coral polyps in all seas, but the corals that build coral reefs and coral islands are very particular in their tastes, and inhabit only warm and clear seas where there are no cold currents, where the mean temperature of the air is not lower than 63° Fahr., and where the mean temperature of the sea is not below 68° Fahr. They do not live near the mouths of great rivers, because of the muddy water; they shun the Somali coast, because the south-west monsoon causes ascending currents, and they avoid the west coast of South America, because of its muddy sea and the cold Polar current that flows along it; but they flourish in the Red Sea, the Persian Gulf, the Gulf of Mexico, the western Indian Ocean; and in the Pacific, their favourite habitat, there are no fewer than 290 coral islands. The Gulf Stream makes life possible for them even in temperate zones, and there are coral islands and reefs as far north as the Bermudas.

But the reef-building polyps require more than climatic advantages; it has been found that they never live below thirty fathoms, nor above low-water mark, and this, of course, greatly restricts their reef-building operations. Nevertheless, in



WAVING PALMS ON THE PENRHYN ATOLL, IN THE MANIHIKI GROUP, PACIFIC OCEAN

NATIVES ON A CORAL REEF AT SAVAGE ISLAND AT LOW TIDE

THE LANDING-CREEK THROUGH THE CORAL BARRIER OF SAVAGE ISLAND

spite of all restrictions, the reef-building polyps have done an amazing amount of work, so that, though coral islands and reefs, as a rule, are small, the total area covered by coral is surprisingly large. The Great Barrier Reef of Australia alone covers an area of 33,000 square miles—enough to cover the whole of Scotland.

The massive formations of coral may be divided into three classes: (1) fringing reefs; (2) barrier reefs; (3) atolls.

Fringing reefs are comparatively small reefs that fringe islands and continental coasts, quite close to the shore, and separated from it only by shallow water. On their seaward side the water is deeper, but still shallow, and the sea floor slopes gradually downwards. Fringing reefs are found off Mauritius, Ceylon, the Nicobar Islands, the West Indies, and the peninsula of Florida. They are also found in the Red Sea.

Barrier reefs are found in the same situations off islands and continents as fringing reefs, but they are more massive, farther from land, and with deeper water both on their seaward and landward sides. So deep, indeed, is the water on the seaward side of these reefs that it used to be considered unfathomable. When the barrier reefs surround islands the reefs are known as "encircling barrier reefs," and the island in the centre is known as a "lagoon island." Many of the South Sea Islands, the Fiji Islands, the Society Islands, the Solomon Islands, Samoa, New Caledonia, etc., are circled by reefs, and within the reefs is a natural harbour to which entrance can be gained only through breaches in the barrier. The reefs are always low, rarely more than ten feet high, and are narrow in proportion to their length. A reef off the west coast of New Caledonia has a total length of 400 miles, and is on the average eight to sixteen miles from land. The Great Barrier Reef, off the north-east of Australia, is nearly 1250 miles long, and has an average breadth of ten to ninety miles. It is from twenty to seventy miles from land, and on its seaward side the sea is in places as much as 1800 feet deep.

Fringing reefs and barrier reefs are in connection with land, but atolls are irregular circlets of coral quite isolated from land. They may be crescentic, or circular, or horseshoe shaped, and much broken up. When the atoll reef is much broken up it looks like a chain of islands. The atolls of circular shape enclose shallow lagoons of beautiful clear, green water. Sometimes the lagoons thus made are entirely cut off from the sea, but more often there are reef-channels which allow entrance into the lagoon. Such lagoons make magnificent harbours; for though in storms the waves break over the reef, the centre of the lagoon remains smooth. Some of the atoll lagoons are a hundred miles across; and there is "accommodation for all the navies of Christendom to ride at anchor."

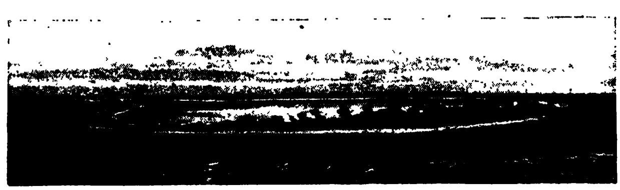
Outside the atoll reef, the sea is usually very deep, and at 2200 yards seaward of the Cocos or Keeling reef 7200 feet have been sounded. Like other reefs, atolls never reach a height of more than ten to twenty feet. The Maldive, Laccadive, and Chagos islands, in the Indian Ocean, are the most typical atolls. The Cocos or Keeling atoll, to which we have just referred, is a good example of a horseshoe atoll. Lakeba and Quiros Islands offer examples of atolls with lagoons completely shut off from the sea. In the atoll lagoons all kinds of marine animals, including sharks, are found, and most atolls are more or less covered with tropical vegetation.

AN ISLAND WITH BARRIER AND FRINGING CORAL REEFS

It may be wondered how these islands obtain soil. Some of it is obtained from the droppings and the dead bodies of sea-birds, some from decaying vegetable matter, sand, and pumice-stone washed up by the sea. Strangely enough, the land-crabs which inhabit most of the islands play a very active part in the accumulation and cultivation of the soil. In certain islands there are hundreds and thousands of these land-crabs constantly scouring the beach and collecting twigs of trees, and seaweed, and scraps of cocoa-nut to bury in their burrows. Other crabs are continually engaged in burying cocoa-nuts and seeds and vegetable matter in the soil. Other crabs industriously turn over the soil. And yet other crabs excavate tunnels in the ground, and line them with cocoa-nut fibres. Thus the waves, and the birds, and the crabs together manage to change the limy surface

of the reef into a dark, rich vegetable mould. Seeds reach the atoll brought from the land by birds which carry them in their crops or attached to their feathers, or adhering to their feet; and other seeds, such as cocoanuts, must be frequently washed ashore. Eggs of reptiles are brought on drifting trees, and may be occasionally stranded, and men may arrive in ships and canoes. In time, accordingly, an atoll gets a flora and a fauna, and becomes a habitable and hospitable island.

Professor Sollas thus describes his arrival at Funafuti, one of the Ellice or Lagoon Islands situated in the middle of the Pacific to the north of Fiji. "The ship was steered for the southern entrance; this was safely made, and we steamed into the noble lagoon. Flying-fish spurted from under our bows, and zigzagged in their darting flight around us; here and there in the midst of the blue waters green and purple shallows marked the site of growing coral patches. On the starboard side lay the beautiful island of Funafuti proper, its pale sands ablaze in the light of the tropical sun, its groves of palms cool with a refreshing green. A boat put off from the beach, manned by a crew of copper-coloured natives, their black hair crowned with wreaths of gardenia and hibiscus flowers. They were soon swarming over our sides, bringing with them the solitary white trader of the island, who safely piloted us to anchor within a mile of the shore. Captain Field and a party immediately landed, and we went at once to pay our respects to the King, who, notwithstanding the narrow limits of his realm and the smallness of his nation, which numbers only some 240 souls, we found to be every inch a King. His Majesty received us with gracious dignity, led us into his palace—one of the few stone huts on the island—and seated us by his side on a daïs which consisted of packing-cases. The chief men sat round the walls on the floor, and smiling damsels, with large black eyes and long black tresses floating loose, shyly presented us with freshly opened cocoanuts to drink—a civility which as inevitably attends a call at Funafuti as the afternoon cup of tea at home."



A CORAL ISLAND, OR ATOLL, WITH ITS LAGOON

The natives of Funafuti came to the island by boat, some finding the island in the course of a long, adventurous voyage, and some having been cast ashore there. Much of the island, according to Professor Sollas's description, is covered with cocoanut palms and other trees, and there are ferns and brightly coloured flowering plants, and " a handsome bean which trails through the forest, bearing large, heart-shaped leaves and heavy racemes of lilac flowers." Other coral islands are equally fertile. Whitsunday Island is covered so thickly with a luxuriant tropical vegetation that no soil can be seen. It certainly is a marvellous thing that these circles of hard lime, springing up like fairy rings in the middle of the sea, should succeed in obtaining soil and plants and animals.

We have said that coral islands are almost invariably low islands, but, still, coral does rise to a height of ten or twenty feet above the sea, and we must inquire how it comes to rise above the water at all, when the coral polyps can work only under water. It would seem that these islands are heaped up above water by the action of the waves, which break off fragments of the outer margin and fling them over into the lagoon. Fragment after fragment, large and small, is pitched by stormy seas in this direction till the fragments are piled above sea-level. Finally, the fragments are cemented together, partly by the action of calcareous algæ and partly by water holding carbonate of lime in solution, to form a solid, irregular plateau.

The height of the coral above sea can be explained in this way, but how are we to explain the great depths from which the coral is upbuilt? If coral polyps will not build above water, neither will they build at greater depths than thirty or forty fathoms, and they do not flourish below six or seven fathoms. How, then, can coral atolls rise out of the deep sea? To this problem Darwin suggested a very interesting and plausible answer. He suggested that atolls were originally fringing reefs that circled islands. The islands slowly subsided, and as they subsided the reefs grew upwards and outwards, and became barrier reefs. Finally, the islands subsided altogether, and the barrier reefs, still continuing to grow upwards, became

atolls. According to this theory, each atoll is "a garland laid by the hand of Nature on the tomb of a sunken island." Of these islands we have no record, but Réclus states that the natives of the atolls of Ebon say that their fathers remembered a time when an island with cocoanut palms and bread-tree fruits occupied the greater part of the centre of the lagoon.

When we consider how many atolls and barrier reefs there are, and the huge areas they occupy—an area in the Pacific Ocean measuring fully 6000 miles from east to west, about 1000 to 1500 miles from north to south—it is evident that Darwin's theory postulates a great instability of the ocean floor; but there is nothing incredible about the postulate, especially since the coral reefs are almost always in volcanic areas and associated with volcanoes, which themselves are signs and symptoms of instability, and for some time Darwin's subsidence theory met with universal acceptance. But soon difficulties became apparent.

The Difficulties in the Way of Darwin's Subsidence Theory

In the first place, it was pointed out that if coral were formed in the sea in such mountainous masses, it was a strange thing that no part of the ocean floor which had been upheaved showed any such immense coral formation. Then it was found that atolls and raised coral reefs may occur within fifty or sixty miles of each other, and in the Solomon Island there are raised coral reefs of all heights from 100 to 1200 feet. In view of these and other difficulties, Sir John Murray advanced another theory which has gained a great deal of acceptance. Sir John Murray's theory is a theory of elevation and solution, and he considers that subsidence has very little to do with the characteristic forms of coral reefs. He maintains that the coral polyps founded their colonies on the summits of volcanic mountains when they rose to a suitable height from the bottom of the sea. Seeing that the polyps will grow only at heights between sea-level and the thirty or forty fathom line, and will really thrive only at six or seven fathoms below sea-level, this theory would seem to require an extraordinary and most unlikely uniformity on the height of the submarine volcanic mountains that are the foundations of atolls. But Sir John Murray's theory does not assume that the submarine mountains which are elevated from the sea floor all reach the same height. It merely assumes that *when*, in the course of their upheaval or in the course of their denudation, they reach a certain height, then the polyps find them a suitable platform for building, and proceed to build. If the peak or platform on which they build continue to rise, they will eventually be lifted, as in the case of the reefs we have mentioned on the Solomon Islands, high above the sea. If the peak subside slowly, then they will build upwards, and maintain their colony at a liveable level.

Difficulties in the Way of Murray's Theory of Elevation

Further, it is not necessary that the peaks should actually themselves rise to the suitable height. Even supposing, as is very likely, that the submarine peaks rise to varying heights, yet those above the right height will be pared down by submarine denudation, and those below the right height will be built up by sedimentation. All the coral islands in the regions of globigerina ooze rise from water teeming with foraminiferæ; and if on the bottom of the sea calcareous sediment accumulates to the depth of thousands of feet, likewise it must accumulate on the submarine peaks, and gradually raise them to a height within reach of the coral polyps. Professor Joly holds that those areas of the ocean bed where sediment is thickest are just those parts which are softest and weakest, because of the heat produced by the radio-activity of the sedimentary material. Accordingly, at those parts the earth's crust buckles or gives way to volcanic force, and we have raised ridges and volcanoes which are still further raised by a rain of foraminiferæ. It is a pretty theory—the volcanic mountains raised by the agency of foraminiferæ, and still further heightened by the corpses of foraminiferæ and other calcareous organisms till they are high enough to serve as a platform for atoll reefs.

The Bringing of Rival Theories to the Test of Practical Experiment

On the top of the peak or elevated plateau there would be first globigerina ooze, then pteropod ooze, then remains of starfish, deep-sea corals, and other calcareous organisms, and, finally, the coral material.

All this certainly offers a reasonable explanation of the rise and emergence of coral atolls, and of the height above sea-level at which coral occasionally is found; but how does Murray explain the shape of atolls? The coral polyps, according to Murray, build at first a flat table of coral rock. As this table thickens and grows upwards, its rim increases most rapidly,

because the polyps situated there are most exposed to the ocean currents, and have therefore the most plentiful food supply. The result is that the upper surface of coral, instead of being flat, becomes concave or saucer-shaped. The rim of the concavity further hinders the flow of currents with food supply towards the centre, and finally, when the rim rises above water, it cuts off food supply from the centre altogether. The result is that the central coral polyps die, and their coral, like dead teeth, softens and breaks down and dissolves, and is scoured out by the sea. Further, as the margin steadily grows outward, the central part, *pari passu*, is dissolved away, and so the atoll grows larger and larger till its lagoon may measure a hundred miles across. The solution of the coral in the lagoon is much assisted by the carbonic acid gas added to the water of the lagoon by accumulations of seaweed. In similar manner a fringing reef will become a barrier reef by rapid increase of its outer surface, and death and dissolution of its landward side.

According to Darwin's theory, the atoll is "a garland laid by the hand of Nature on the tomb of a sunken island." According to Murray's theory an atoll is "a wreath of victory crowning a youthful summit on its first conquest of the main."

Both Darwin's and Murray's theories found supporters, and a controversy raged and is still raging. It occurred to Professor Sollas that the matter might be settled "by sinking a borehole through some well-characterised atoll, and thus obtaining specimens of the material of which it is composed down to a depth considerably greater than that at which corals are supposed to build." If Darwin's theory be correct, coral substance should extend down far below the life-limits of the coral polyps; if Murray's theory be correct, then layers of chalky ooze should begin at a depth of thirty or forty fathoms.

FLOWERS OF THE EASTERN SEAS—CORAL REEFS OF A POLYNESIAN ISLAND

Professor Sollas organised a coral-boring expedition, obtained the free loan of a diamond drill from the Government of New South Wales, and proceeded to Funafuti, the atoll we have already mentioned. The first attempts at boring were unsuccessful, the machinery was insufficient, the reef was difficult to bore, and a borehole deeper than 105 feet could not be

made. A second expedition, however, was more successful, and deepened the borehole to 698 feet, and finally a third expedition achieved a depth of 1114·5 feet.

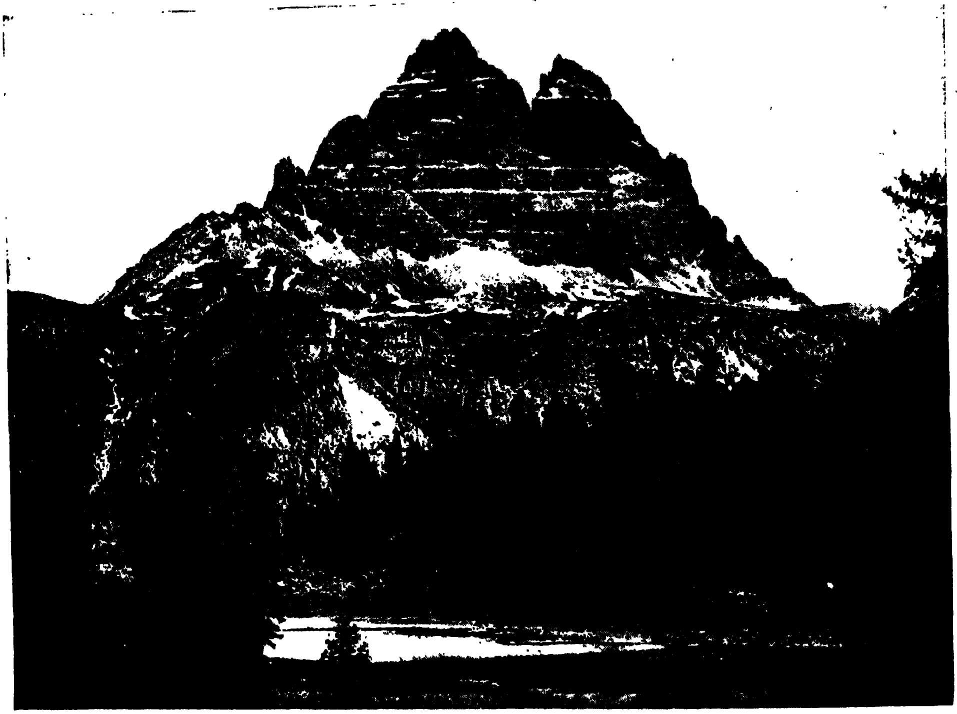
The material obtained was cut into hundreds of thin, transparent slices, and subjected to careful microscopic examination by an expert; and the following inferences and conclusions were reached: "(1) The limit of reef-building growth does not exceed, if indeed it reaches, a depth of 45 fathoms below the level of the sea; (2) true reef-rock was passed through in the boring from the surface down to 185 fathoms; (3) no rock other than reef-rock was encountered, and in particular no Tertiary limestone; (4) the structures met with were such as to exclude the notion that the reef had grown upwards on talus of its own *debris*.

"From these inferences but one conclusion appears possible, and we must admit that this atoll at least has been formed during a subsidence of the foundation on which it rests, a subsidence which must amount to at least 877 feet."

The result, then, of boring the reef was to support the theory of Darwin rather than the theory of Sir John Murray.

The question of the manner of the making of atolls may seem a very small one, but, like many other apparently small scientific problems, it has large relevancies. The history of the atoll is part of the history of the ocean floor, and therefore of the history of the earth's crust; and a study of coral formation and even of coral chemistry may elucidate many geological problems. For instance, in the course of the investigation we have mentioned, it was found that the deeper coral limestone contained as much as 40 per cent. of magnesium carbonate, and that a calcareous alga was distributed over the floor of the lagoon. Now, the dolomite peaks of Tyrol are found also to contain a large percentage of magnesium carbonate, and to have calcareous algæ in their composition; hence the view that they were once coral reefs receives certain confirmatory evidence. A little coral lime brought up from the heart of an atoll in the Southern Pacific thus throws light—we might almost say lime-light—on the great spectral mountains which cast a spell over all who have penetrated to the recesses of Tyrol. The changes of those splintered peaks are not less dramatic than that imagined by the poet who saw how

> Where the long street roars hath been
> The stillness of the central sea.



MOUNTAINS OF TODAY MADE BY LIFE BENEATH THE SEA—THE DOLOMITE DREI ZINNEN

THE CONQUEST OF PAIN

The Various Drugs that Cause Insensibility, and How They Were Brought Into Use

THE FIGHT FOR PAIN MADE BY RELIGION

We have already seen that the psychical fact called sensation, or feeling, is as old as life. As life ascends this fact of sensation was found to become more conspicuous, more important, more specialised, and vastly more intense. In our own species, and in all of those which are allied to us in any close degree, a special sense of pain has been developed, *for vital purposes*, just as other special senses, of sight and hearing, have been developed. To suppose that the sense of pain is a mistake or a piece of malice on the part of the evolutionary forces is never to have spent a moment's thought upon it.

The familiar adage that "the burnt child dreads the fire" not merely tells us the value of experience, but it also tells us the value of pain. That which is painful is also very likely to be harmful, or even deadly—like fire, or the knife which, cutting through the layer of skin in which the nerves of pain end, is liable to go on until it severs blood-vessels and causes death by hæmorrhage, or the pin which, similarly striking the nerves of pain, may introduce microbes and cause an abscess. Pain is unquestionably useful and necessary, but whether it is useful and necessary for the reasons commonly given in sermons is another question. The shocking record of the clerical reception of anæsthesia may well give us pause before we accept the conventional interpretation of pain. More rational, more humane, and more profound is the scientific view of pain as a protector of the body rather than a purifier of the soul—which, indeed, chronic pain too often seems to spoil and sour.

Let us have our underlying philosophy sound and clear. According to an obsolescent theology, pain was good in itself. Science has no evidence of any such thing. Pain is not good in itself, at any rate with but rare exceptions, because it weakens the body, disturbs the action of the nervous system, interferes with digestion and nutrition, and, above all, with sleep. If pain is good in itself, then sleep is bad in itself—which is absurd. The value of pain is as an indication and a warning; and therefore, while the biologist and the biological physicians value it, they simultaneously seek to remove it. They know well that if a hot bottle be left against an anæsthetic limb, ruinous harm may be done, because the patient, feeling no pain, does not withdraw it. Thus, and thus only, is pain to be valued in the scientific sense.

We are therefore entitled to control it when and where it serves no vital purpose. The pain which leads one to avoid a hot surface is vital; the pain of a burn tends to be mortal. The pain which, destroying sleep, produces melancholia, leading very likely to murder or suicide in too many persons, cannot be regarded as a Providential dispensation. On ultimate moral grounds, we are entitled to control it if we can.

But one special case of pain may be regarded as an exception, at any rate by members of the sex which is not called upon to endure it, and that is the pain of childbirth. As we look back nowadays, it is almost impossible to credit the state of dark and hideous superstition in which most of our parents or grandparents lived, as lately as the middle of the nineteenth century. When a humane man of genius, whose work we are about to discuss, introduced means whereby the pain of childbirth could be relieved, the clergy of all denominations, with almost unanimous voice, declaimed against him as impious, for seeking to avert from womanhood the penalty which the sin of Eve and the fiat of Deity had imposed, and suggested that, without this salutary discipline, the good

behaviour and morality of women could no longer be guaranteed. These worse than fools were silenced by their adversary, who, answering them according to their folly, pointed to the record that when God created Eve out of a rib taken from the side of Adam, he first caused a "deep sleep" to descend upon his patient—as surgeons do today in cases of birth.

In this discussion we shall assume that all the powers of the human mind may rightly be employed for whatever purposes are pure and kind and lovely and of good report. The relief of dangerous pain at any time, and in both sexes, is one of these.

The Oldest and Most Famous Means of Relieving Pain

This is a subject which lies somewhat apart from the "conquest of disease" in the ordinary sense, but for certain great practical purposes, in the establishment of our species in the world, against other forms of life, the conquest of pain is practically essential, and so cannot be omitted here.

Incomparably the oldest and most famous of all means whereby pain may be relieved is the juice of a certain plant called *Papaver somniferum*, the "sleep-bearing poppy." The juice which exudes from incisions made in the capsules of this poppy, and which soon dries, is called opium, and no imagination can serve to realise the sum total of human pain which this most blessed drug has relieved. It contains a number of active principles, several of them directly antagonistic to each other, and the invaluable agent in its composition is the alkaloid morphine, often called morphia for short. It is, of course, a poison, and its poisonous effects, both acute and chronic, are only too well known, whether in cases of laudanum poisoning—laudanum is an alcoholic tincture of opium—or of "morphinomania." The action of the drug is both upon the brain and upon the endings of the nerves of pain, and to this double action it doubtless owes its unique power in many cases. But while the "peripheral" action upon the nerve-endings is devoid of danger, the "central" action may very well extend further than is required.

The Use of Opium to Procure Insensibility too Dangerous to be Admissible

This drug, like the others which have to be discussed, and like many other injurious influences, attacks the activities of the brain in an order which is the opposite of their historical order. "Last to come, first to go" is the rule. With morphine there is, no doubt, a considerable interval between the action of the drug on the highest centres and its action upon the vital centres, which control the working of the heart and lungs from the bulb of the brain. But the tendency of the drug is to extend its action from above downwards in dangerous fashion, until finally the patient dies of asphyxia from the death of his "respiratory centre." And the dose of the drug which will totally abolish all sensibility to pain, even to the surgeon's knife or the throes of childbirth, is so near to the deadly dose that its use is impracticable for such purposes, even had it no other disadvantages. It may be, and is, occasionally used in some cases as an adjunct to other drugs, but as a general anæsthetic its action is too close to death for us to employ it.

Before the nineteenth century men had practically no choice, therefore, but to endure pain as best they could. When a certain extremity of agony was reached, the action of the heart was likely to be interfered with by the vagus nerves, and the patient would faint. So much mercy alone was vouchsafed. Yet the need was so desperate that men sought anything, however imperfect, rather than nothing.

The Places of Alcohol and Nicotine as Pain-Killers

Alcohol is a typical anæsthetic, largely employed in combination with others today. Many a drunken man, who has fallen and dislocated his shoulder or broken his thigh, has had the dislocation reduced or the fracture set before he recovered from his drug sufficiently to feel pain. Thus alcohol could be employed, but the objections to its use were formidable.

Another familiar drug is the nicotine, as we know it, in tobacco. Sometimes, when a dislocation had to be reduced, and the involuntary pull of the muscles in the neighbourhood was so powerful that, short of increasing the damage, no surgeon, nor any number of surgeons, even with the aid of pulleys, could get back the head of the thigh-bone (as it usually was) into its place, recourse was had to the deadly, sickening, almost anæsthetising action of tobacco in excessive doses. It might be smoked or chewed or otherwise introduced into the body. This desperately poor best was the most man could achieve until the dawn of the nineteenth century.

Therewith began a new era, with successive stages marked by the names of three chemical compounds—nitrous oxide, sulphuric ether, and chloroform. The first of these, familiar to all as the "laughing gas"

of the dentists, was studied, in the very earliest years of the century, by its discoverer, the great chemist Sir Humphry Davy, to whom we also owe the safety lamp. Davy very nearly killed himself with some of his experiments, but he survived to show that nitrous oxide can be inhaled, with abolition of consciousness and of sensibility to pain, and with complete recovery after a few seconds. This beneficent drug is worthy of some accurate study.

The Value and Safety of Nitrous Oxide as an Anæsthetic

It is one of the five compounds between nitrogen and oxygen, its molecule containing three atoms, two of nitrogen and one of oxygen. When the gas is inhaled with air, it often produces exhilaration, excitement, and somewhat unbridled behaviour, and even hallucinations of a type which have often led to the making of utterly unfounded charges against those administering the drug. But nowadays this initial stage of excitement, which we observe with all the anæsthetics we know—alcohol, chloroform, ether, nitrous oxide, morphine – and which is due to paralysis of the highest faculties of self-control and judgment, before anything else goes, can usually be cut so short as to be unrecognisable.

The gas must be inhaled in such a fashion that the patient gets no air at all. Thus deprived of oxygen, the very breath of life, he has little chance of displaying excitement, and in a very few seconds he is unconscious. The writer's statement depends in part upon a considerable personal experience, as a patient as well as an administrator of this anæsthetic and of the other two which we owe to the nineteenth century. Anæsthesia, properly induced by nitrous oxide, may last as long as ninety seconds, at the outside; and it is doubtful whether, in a healthy person, any fatality has ever been recorded from its sole use, apart from such an accident, once, at any rate, recorded, as swallowing a portion of the apparatus.

The Method by which Nitrous Oxide Acts—Temporary Oxygen Starvation

It may well be asked how this drug can abolish consciousness and sensibility to pain so quickly, and for such a comparatively long period after the dose is discontinued, without danger; and the apparent answer is very interesting. It is that the drug so acts upon the red cells of the blood, especially upon their red colouring-matter, or hæmoglobin, which conveys oxygen from the lungs to the tissues, that this conveyance is no longer possible while the nitrous oxide is in possession, so to say, of the hæmoglobin. Thus, even for some time after the dose has been discontinued, and the patient is breathing air again, consciousness is arrested, for the nervous tissues do not receive from the blood the oxygen which they require. What it means to the brain to be deprived of oxygen, even for a few seconds, anyone may guess who has seen a neighbour faint, or may experience who, having shut one eye, presses firmly upon the other eyeball, when blackness will come over his vision in a few seconds, because his retina is starved of oxygen.

When the oxygen starvation is achieved by nitrous oxide, the beauty and safety of the method depend upon the fact that the removal of poisons from the body is not interfered with. The patient is deprived of air; but to be deprived of air, even for some minutes, or even hours, is not to be killed, if the carbonic acid produced by the body can meanwhile escape. In the air expired by the patient who is inspiring nitrous oxide alone, carbonic acid is to be found, formed from the oxidation of his muscular tissues by the small but real quantum of oxygen which is stored up within their living protoplasm. It is the completeness of excretion that protects the patient who is under the anæsthetic influence of this invaluable drug.

The Excellence of Nitrous Oxide in Swiftly Abolishing Consciousness

But, of course, there is a limit to the period during which we can be kept going by the oxygen stored up within the cells of the heart muscle and the respiratory muscles. Hence the administration of nitrous oxide cannot be indefinitely maintained. If the surgeon cannot do his work in something like a minute, the drug will not avail. Something more is required. That something is now at hand, but until quite lately the mistake was made of supposing that nitrous oxide was therefore of no use in ordinary surgical cases. The writer can testify otherwise, and has every kind of experience to justify the assertion that, within the last decade, a great advance has been made in anæsthetic procedure by the practice of giving nitrous oxide first, which means safely abolishing consciousness in four or five seconds, and then maintaining the anæsthesia with ether or chloroform or the "A. C. E. mixture," which is so called because it consists of alcohol, chloroform, and ether. No other substance than nitrous oxide is known to science that will safely and wholly abolish consciousness with

anything approaching the practical instantaneousness of nitrous oxide, which is as quick as a faint.

We now pass on some four decades, until the early 'forties of the nineteenth century, and the introduction of the anæsthetic use of ether, a great boon which we owe to the United States of America. We need not here concern ourselves with the long and bitter controversy as to priority which, unhappily, disfigures the records of this event. Ether, or sulphuric ether, had not long been discovered. Sulphuric ether is so called because sulphuric acid is employed in its manufacture, and because of the "ethereal" quality of its appearance—it is an intensely volatile, colourless liquid at ordinary temperatures—and of its odour.

The Use of Ether in Securing Long-Continued Unconsciousness

Chemically, it is very closely related to alcohol, to which it has a close physiological affinity also, even being consumed for purposes of intoxication in some parts of the world. It is very volatile and very inflammable, disadvantages of a formidable kind in many cases and places—as upon the field of battle. Nevertheless, here is a drug which, in its gaseous form, can be inhaled as a constituent of the air which the patient breathes, and which, thus inhaled in certain proportions, will abolish consciousness and sensibility to pain. The state of "general anæsthesia" thus induced can be kept up even for hours, if necessary; and if the proportion of the gas in the patient's blood is not allowed to exceed a certain quantity, the action of the heart and of the lungs will proceed safely all the time.

The subsequent introduction of another drug, more powerful than ether, and in many ways more useful, must not blind us to the fact that ether has, and will have, certain advantages of its own. We are heirs of the long controversy between advocates of ether and those of chloroform, and, rather than take sides now, we may take what is useful and true from both sides.

Controversy Between the Users of Ether and the Users of Chloroform

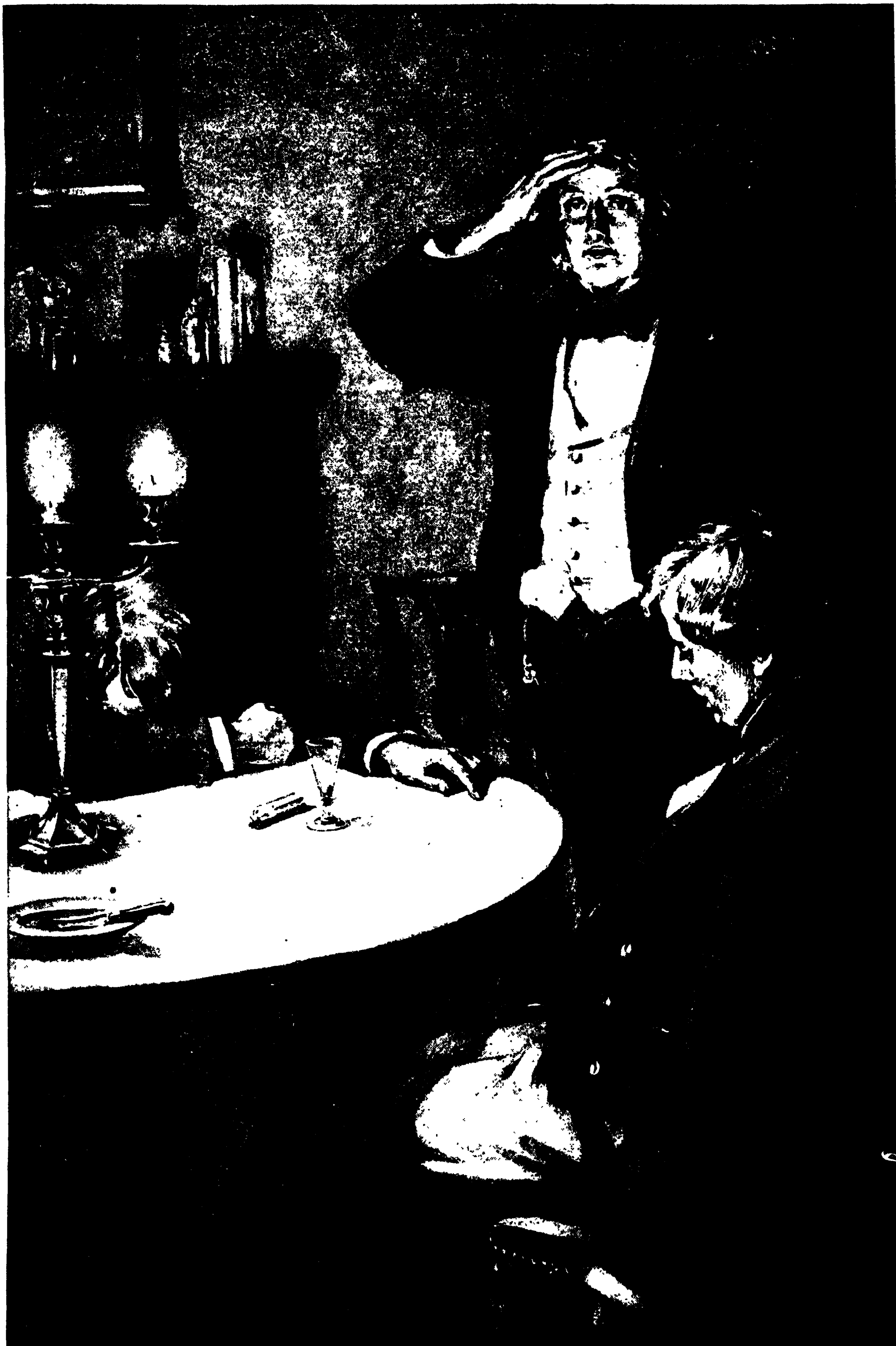
Many surgeons and anæsthetists, having begun with the use of either drug, continue it thereafter, finding no reason for change. The fanatical partisans of twenty years ago and more are dying out. The drugs must not be compared except under equal conditions. Both must be pure, stored in dark bottles, kept away from the light. The Edinburgh surgeons used to consider that pneumonia and bronchitis, due to the irritation of the lungs by the drug, were far commoner with ether than chloroform, and that, though chloroform caused a larger proportion of fatalities during the operation, ether was more dangerous after it. But so much depends upon methods of administration, and upon the *proper preparation* of the patient before operation, where this is possible, that the actual identity of the drug employed seems to matter much less than used to be supposed.

In certain kinds of cases one or other of them is vastly to be preferred—as, for instance, ether where the heart is weak, chloroform in childbirth and upon the battlefield. Ether causes far more initial excitement, which is highly objectionable in many cases, weakening the patient's resources of energy. But nowadays no first-class anæsthetist permits any initial excitement to occur at all, for he begins with nitrous oxide, and so that argument need no longer be considered. On the other hand, there is much reason to believe that the higher proportion of fatalities ascribed to chloroform, only as late as ten years ago, was associated with the retention of the "open method" of administering it, which involved great and dangerous variations in the dosage which the patient received, and which was only practised by Edinburgh surgeons and their pupils because it was the natural method employed by the introducer.

The Extraordinary Manner in which the Power of Chloroform Was Established

Thus we pass to the third and last stage in the history of general anæsthesia, the discovery of the anæsthetic property of chloroform, and its introduction into obstetric and surgical practice by Sir James Simpson (1811–1870) in Edinburgh in 1847. Simpson was a humane man, and his attendance, as a student, at the first surgical operation he saw nearly caused him to abandon his profession. What an operation, say, for excision of the tongue and half the lower jaw, meant in those days none of us can now even imagine, fortunately for ourselves. Simpson specialised in obstetrics, and wanted some drug that should relieve the agony of childbirth, and especially a drug that would enable the obstetrician to be more useful in difficult cases. Ether was not good enough, and Simpson sought for something better. Those were not the days of synthetic chemistry, when the actions of a compound can be predicted from the structure of its molecule, and when the molecule can be reshaped according to requirements, as in the modern

AN INCIDENT IN MAN'S FIGHT WITH PAIN



SIR JAMES SIMPSON AND HIS FRIENDS MAKING THE FIRST TEST OF THE POWER OF CHLOROFORM

cases of such drugs as trional, atoxyl, "606," etc.

Simpson gave orders that any promising drug or new compound discovered by the chemists was to be sent to him. He and a very select company of friends met regularly in his dining-room, and after dinner, as they sat round the table—where, long years afterwards, the present writer has often sat and thought of its past history—they each inhaled the vapour of one promising compound after another, hoping to find something which should be better than ether. For long their experiments led to nothing. The compound called chloroform had been discovered by the great German Liebig some years before, and a sample of it was latterly included among the various chemicals which were sent to Edinburgh. But chloroform is a heavy liquid, almost syrupy to look at, and seemed too unlike the volatile, glittering ether to be promising. The experimenters only tried it when there was nothing else to go on with. . . . When Simpson came to, he found himself surrounded by his prostrate friends, who had succumbed, and his first thought was: "This is much better than ether." The anæsthetic action of chloroform had been discovered, thanks to the courage and persistence of the honourably and uniquely intoxicated company round that table.

The Overthrow of Obstinate Ignorance by a Personal Act of Queen Victoria

The real battle had yet to be fought, and, as we have already seen, it raged over questions of moral and religious principle, which we have already tried to define from the standpoint of today. When a surgeon tried to relieve the pain of an operation with ether, no one who did not also object to the use of opium for suffering could very consistently criticise. But when Simpson proposed to relieve the natural pain of childbirth, the followers of Him who "went about doing good," were outraged. We have seen how admirably Simpson replied to such antagonists. He had no less to meet at the hands of his professional colleagues. Harvey lost nearly all his practice, thanks to his colleagues' opinion of him for presuming to discover the circulation of the blood. The surgeons of the 'forties hated Simpson, who was not even a surgeon, for his discovery and his success, but chloroform was too precious a boon to be gainsaid.

The drug was successfully administered to a mother in childbirth, a mother brave enough to inhale a drug never before thus inhaled, and to face the physiological and eternal consequences alike; the child was born unharmed, and was named Anæsthesia. A portrait of her always stood on Simpson's desk. But for some time the new boon for suffering womanhood made its way but slowly. Then Queen Victoria, following the advice given her by her own physician, one of the exceptions, inhaled the drug for the birth of one of her own children, and no one worried about Genesis any more. The triumph of chloroform was complete.

Those who remember the little ceremony of 1897, in the University of Edinburgh, when the jubilee of chloroform was celebrated, might have wondered then, and must wonder much more now, that so many years should have passed without the supersession of a drug which, after all, was found without any help from theory, in days when the chemistry of drugs was in its infancy.

The Remarkable Safety of the Normal Administration of Anæsthetics

Many other drugs have been tried, but the fact remains that the three which we have described, and for whose introduction the nineteenth century will be remembered when a great many of its most boasted theories and explanations of the Universe and Man and Destiny are forgotten, still hold the field. What advance is to be recorded mainly consists in improved administration of these familiar drugs, in more accurate knowledge of the dosage that is safe and effective, and in more attention to the preparation of the patient.

These are by no means trifling matters, and their observance in experienced hands now renders the inhalation of an anæsthetic a far safer proceeding, statistically considered, than many in which we daily engage without a thought. Except for the rare disorder of development known as the *status lymphaticus*, and apart from cases of extreme weakness or heart disease, it is probable that the administration of anæsthetics today, by the expert anæsthetist, is as nearly *safe* as anything can be.

Advance Made in Administering Drugs and in Preparing the Patient

The advance depends, first, upon improved administration. Simpson sprinkled the drug on a towel, and held the towel more or less closely over the patient's face. This is the so-called "open method," and though it may be very suitable in cases where only light anæsthesia, as a rule, is required, as in childbirth, it must be condemned in surgery. Both for ether and for chloroform we require a device, a specially made inhaler, whereby we may produce a definitely known

and modifiable mixture of the drug and of air which the patient inhales. If the proportion of the drug in the inhalation mixture is *never* allowed to exceed a certain quantity, then the proportion of it in the patient's blood can never exceed a certain quantity either; and that quantity can be kept far below the figure of danger experimentally ascertained by physiologists.

Lastly, the patient's diet, where there is time, can be regulated; no food of any kind, liquid or solid, is permitted for several hours before the operation, and steps are taken to have the whole of the digestive canal empty and at rest. This puts an end to the somewhat misunderstood "ether bronchitis," or what not, which was probably due to the inhalation of particles of food which reached the throat when the patient was sick, rather than to the drug itself. Wisdom and care before and after the operation reduce struggling and sickness to a minimum, often to nothing at all.

How do chloroform, ether, and similar anæsthetics act? Unquestionably by a local action upon the cells of the cerebrum concerned with consciousness and sensation. To some slight extent we are acquainted with the details of the action.

The Search for Local Instead of General Anæsthetics

Chloroform, ether, alcohol, and the other drugs which have this action seem to agree in their chemico-physical properties, in that they are able either to dissolve, or else to soak through, the fatty envelope of what is called "lipoid" matter that seems to surround nerve cells and protect them. Most of the substances which are found in the blood are excluded by this lipoid barrier. "Colloids," as they are called—that is, glue-like substances—cannot get through it, but certain "crystalloids" can, and then they act upon the nervous protoplasm according to their powers. So much, at any rate, we think we know.

But how vastly better, on almost every ground, it would be to have a drug, or drugs, which dealt *locally* and *exclusively* with the seat of pain, wherever it was, instead of having to attack the very citadel of our being in a fashion which, at its best, has many objections, and is entirely debarred in hosts of cases of pain! What we want is a "local anæsthetic," instead of a "general anæsthetic," and we should like to be able, safely and without subsequent disadvantage, to relieve all forms of pain, acute or chronic—the pain of headache, of gallstones, of a burn, of toothache, or anything else. First, if possible, we must remove the cause, but where we cannot remove the cause we should like to relieve the pain. Now, one cannot very well chloroform a poor, wasting baby, because its heart is in danger enough of giving out already, and yet its sufferings are lamentable. Hence the search for local anæsthesia applicable to all cases. Along this line great advance is being made. A few notable stages in this most important aspect of the conquest of pain must be detailed.

A Drug that Relieves the Agony of Acute Heart-Spasms

It is said that probably the most intense and deadly pain known to mankind is that associated with attacks of the disease called angina pectoris, from which, without any relief from his own chloroform, Simpson suffered and died. None of the anæsthetics we have named would relieve angina except at the cost of death. But, now many decades ago, when still studying medicine in Edinburgh, the famous physician and student of drugs now known as Sir Lauder Brunton discovered the properties of a drug called amyl nitrite—minute traces of which give their flavour to the familiar sweetmeat irrelevantly known as "pear-drops"—which, when inhaled, dilates the blood-vessels with great speed and intensity. He thought that this drug, opening the sluice-gates of the circulation, might relieve the heart's angina—that is, "writhing"—when the attacks came on. It does so, and for many years amyl nitrite and other nitrites, occasionally substituted, have relieved many men and women from the most awful pain that is known, and from the acutely conscious sense of impending death which is its characteristic accompaniment, and which is the nearest known approach to the fictitious "death agony" of popular imagination. In some other conditions of pain due to involuntary muscular spasm the nitrites are very valuable, and they have their place in relieving the somewhat similar distress of asthma.

Freezing as a Method of Diminishing Local Pain

But for the more ordinary forms of pain, due to acute stimulation of the nerve-endings in the skin and elsewhere, we need, if possible, a drug that paralyses the activity of those nerve-endings, and does nothing else. Anything which will empty the affected part of blood, and lower its temperature, even to something like freezing-point, for a few seconds, may be of service. Thus

at one time dental surgeons, in cutting sensitive teeth, tried the application of ethyl chloride or other substances which evaporated with great speed, thus "freezing" the part for a few seconds. The remarkable drug adrenalin, the active principle of the adrenal glands, or "suprarenal capsules," as they used to be called, causes extreme contraction of blood-vessels, being the exact physiological antagonist of amyl nitrite, and if this drug be applied to a congested and sensitive mucous membrane much diminution of pain may follow.

Cocaine, a Useful but Dangerous Drug that is Being Superseded

Or the adrenalin may be combined, as is very common nowadays, with the valuable and potent drug cocaine, an alkaloid obtained from the coca plant of the Western Hemisphere. Cocaine has a general action upon the whole nervous system, and may induce a "habit" which is worse than alcoholism, or even, perhaps, the morphine habit. This is not a drug to be lightly handled and prescribed, therefore, and the opera singer who finds how a cocaine spray relieves and tones up the throat is liable to discover that he cannot do without it. But, properly employed, cocaine is a great weapon of mankind in the conquest of pain. Injected under the skin, it dulls sensibility to such an extent that an incision may be made painlessly, or, when the drug is properly applied inside the mouth, a tooth may perhaps be thus extracted without pain.

But cocaine is rather uncertain, and not always sufficiently powerful, in its action. In recent years, increasing attention having been paid to "local anæsthesia," other drugs, most of them close chemical allies of cocaine, have been employed for similar purposes such as eucaine, novocaine, stovaine, etc. Some of these are doubtless superior to cocaine, just as trional is superior to sulphonal, and the conquest of pain is accordingly indebted to modern analytic and synthetic chemistry.

Some Recent New Departures in the Use of Anæsthetics

Quite recently, a surgeon in London has published accounts of the relief of pain by means of a very simple solution chiefly containing the familiar substance urea, which is a product of our own bodies. It appears that this solution can be so applied as to isolate any superficial part of the body, and that too for prolonged periods—even ten days or a fortnight in the case of a bad burn—and without any obstruction to the course of the healing process in such cases. If, as is to be hoped, further observations confirm those which have already been made, the conquest of pain will be extended to an area hitherto unassailed, and to many most distressing cases where our most formidable weapons have been useless.

Another advance of an entirely different kind has depended upon our new knowledge of the tracts of pain in the spinal cord. Knowing where and how the nervous fibres travel from the body to the brain, we might be able to interfere with their conductivity at some level in the spinal cord, so that no pain is felt, and, at the same time, the patient's consciousness is unaffected. This would be neither the "general anæsthesia" induced by, say, chloroform, nor the "local anæthesia" induced by, say, cocaine, but what may be called a "spinal anæsthesia." Much excellent work has lately been done in this direction, so that the surgeon, the physician, and the obstetrician are always having the number and variety of their weapons against pain added to. In many nervous patients a general anæsthetic is far the best, because it is better that the patient should be unconscious, as well as insensitive to pain, during an operation.

The Conquest of Pain and Advance of Surgery Made Possible by Anæsthetics

In other cases a general anæsthetic may be dangerous, and yet a local anæsthetic may be inadequate. If the area in question is not the face or scalp, for instance, but, perhaps, the leg, then the tract of nervous matter which conveys sensibility from it to the brain can be attacked somewhere in the spinal cord at a sufficient distance from its upper end—which is near the vital point, or respiratory centre—to be quite safe. By the injection of anæsthetics, especially of the cocaine type, into the membranous bag which surrounds the spinal cord, perfect anæsthesia can be obtained of the parts of the body which are served from the part of the cord below the level anæsthetised, and any operation may be painlessly performed. Several cases are recorded where, the patient being also a surgeon, he has assisted in the operation upon himself, or has even performed upon himself a major operation, such as removal of the appendix, with as much *sangfroid* as we display when we merely cut our nails.

So much for general, local, and spinal anæsthesia, as now induced by the various means we have stated. Not only do they relieve actual pain which would otherwise

be endured during the period of their action, but they render possible a large and increasing number of surgical procedures which were totally beyond all conception in the days before anæsthesia, and the result of which is to relieve pain far greater in amount that any that the knife inflicts. The pain of gallstones, of similar concretions elsewhere, of many tumours, of dislocated cartilages in the knee joint, of appendicitis, and of a host of other painful diseases is now daily relieved and put an absolute end to by means of surgical procedures which would be impossible without anæsthesia.

The Value of Anæsthetics in Producing Quietness as Well as Relieving Pain

We shall shortly see that this important part of the conquest of pain is very far from being due to anæsthesia alone, but nearly the whole of it would be impossible without anæsthesia. Even in cases where the patient could manage to endure the pain, and survive the shock of it, the involuntary and uncontrollable movements of muscles, due to the surgeon's actions, would make the operation impossible, but the anæsthetic ensures motionlessness as well as insensibility to pain, and so makes possible the many operations which no surgeon could otherwise venture to undertake.

As for the "curse of Eve," the Divine blessing of knowledge has averted it. Let anyone reckon the number of births per annum in a population of forty millions, and the very large proportion of them in which chloroform is used, to say nothing of the many cases in which, without it, the lives of mother and child could not be saved, and it will be seen that the introduction of this drug into the lying-in room was one of the greatest boons of all time.

The Almost Complete Modern Conquest of Racking Pain

The conquest of pain is very nearly complete. Very few forms of pain are now uncontrollable. For even the terrible headache of cerebral tumour, surgery can afford much relief today, through the hands of such men as Sir Victor Horsley. The pain of most forms of inflammation can be safely relieved by the resources of ordinary surgery, such as any man of ordinary competence can practise; the normal, natural pain of childbirth—a pain which is only normal and natural in very few modern women—can be readily and safely relieved. There remains only the so-called "death agony," a potent instrument of ecclesiasticism in the past; but Sir William Osler and others have shown that, on the whole, the so-called "death agony" is a figment. There are very rare exceptions, as in cases of strychnine poisoning. But the usual—if we may not, indeed, call them the normal—forms of death are associated with no "agony" of mind or body. The rule is that we die as we fall asleep, and largely for the same reason.

In our discussion of anæsthesia and anæsthetics we have omitted the oldest anæsthetic of all, with which Nature "puts us to sleep," whether or not we are to wake again here. This anæsthetic is carbonic acid, the proportion of which in the blood accumulates somewhat in ordinary going to sleep, and much more in the usual forms of death. This gas is a definite anæsthetic, and has been experimentaly employed for the purpose by man. Nature usually puts us to our last sleep by means of it. The breathing becomes shallower and shallower, the circulation slower and slower. The merciful gas accumulates in the blood, and our consciousness slowly fades, as when we sleep. Often the observers can say, as in Hood's lines

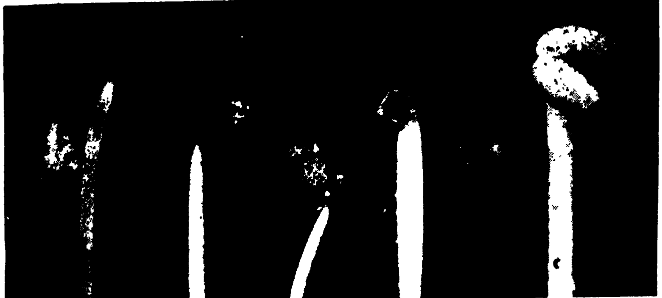
> We thought her dying when she slept,
> And sleeping when she died.

The Imaginary Terrors with which the Deathbed has been Invested

The limbs may often jerk, as indeed they often do when we go to sleep at nights, and some imaginations, especially of the cruel or the morbid kind, may contrive to invent a "death agony" for such quite painless and unconscious convulsions. But we die as we have often slept, returning to the supernal peace of the Divinity whence we came. With this tribute to the mercy of Nature we close our account of anæsthesia and of anæsthetics, from the first to the last, which is the oldest and kindest of all.

Far too long have the facts been misunderstood. The conventional view of death and its agony is well represented by Cardinal Newman's well-known poem "The Dream of Gerontius." The spirit is supposed to be tortured with apprehension and remorse, and to rack the body when about to leave it for ever. The truth is that this kind of deathbed is the rarest ever witnessed by the physician; and even when anything like it is found, the influence of morbid ideas, for which Nature cannot be blamed, is usually responsible. We cry when we are born, because it is necessary that we shall vigorously use our lungs, but our little life is "rounded with a sleep."

THE FERTILISING ORGANS OF FLOWERS

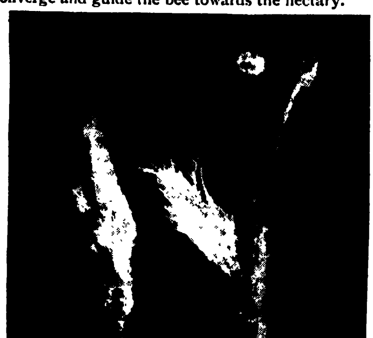


This picture, reading from left to right, shows the magnified stamens of the flowers of fuchsia, African lily, tiger lily, garden nasturtium, snapdragon, begonia, and foxglove, with the anther sacs fully developed, ready to burst and shed their pollen.

Flower of common chickweed, showing five dark sepals, five white deeply cleft petals, the stamens, and three stigmas.

The mouth of a foxglove bell, opened out to show the oval stamens and the projecting stigma. Only the hairy back of a humble bee seeking nectar can brush against these. The spots and hairs within the corolla converge and guide the bee towards the nectary.

The thrum-eyed and pin-eyed flowers of the primrose. The former has stamens at the mouth and the stigma midway down the tube; the latter has the stigma at mouth and stamens below. Bees can thus cross-fertilise these plants in two ways.



Female and male flowers of the palm-willow; the female consists of ovary, scale, and nectary; the male of two stamens, silky scale, and nectary.

FUNCTIONS OF THE FLOWER

Its Structure and Component Parts, and Their Relation to Each Other in Continuing the Life of the Species

THE ENDLESS MARVELS OF ADAPTATION

We are now approaching the conclusion of the consideration of the life of a plant from the point of view of its individuality, though we have yet to consider one or two aspects of plants regarded as societies. So far, we have been mainly concerned in an endeavour to trace out as clearly as possible the varied aspects of the life-history of the plant, and to see what are the different factors which determine the course of the individual plant's existence and constitute its environment. Two products of an individual plant, however, still remain for our consideration, and we have left them purposely until the last because they are the final products for which the plant lives its life. We refer to the flower and the fruit. It is the former which we shall consider in this chapter.

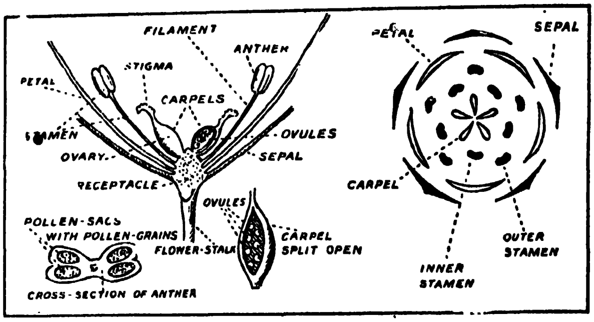
Already we have learned a good deal about flowers in this connection. We have studied how their colours act as a means of attracting animals to them; we observed how the scent of the flowers has a somewhat similar and even more important function. As the result of these attractions we observed the manner in which an entrance is gained to the interior of a flower, and how the creatures who sought to gain that entrance are received there. Something was said as to the taking up of pollen by insects, and its deposition by them, and other means of distribution of pollen were noted in connection with wind and water. All these topics have a more or less direct bearing upon the subject of the flower, but still it remains for us to concentrate our attention upon the structure of the flower itself, its different parts, and their functions.

Of all objects in natural science, probably flowers would be universally deemed the most attractive. "The universal heart of man blesses flowers. They are wreathed round the cradle, the marriage altar, and the tomb." They are, perhaps, the very first objects which attract the admiring attention of young children, and certainly afford to our senses the purest of gratifications. Tastes and ideas differ about almost everything else in this world, but it is probably the truth to say that there is not a man, woman, or child who is not a lover of flowers. It is not, of course, at all necessary to understand a flower in order to love it, any more than it is in the case of a human being; but flowers become of tenfold interest when one realises all the beauty of their wonderful structure, and the marvellous adaptations for the performance of function which they exhibit.

What is the flower? Perhaps the most condensed definition, from the point of view of the botanist, would be to say that it consists of the organs of reproduction of the plant. These, however infinite in their variety of structure, colouring, and arrangement they may be, possess as essential organs, in all cases, the structures termed *stamens* and *pistils*. In addition, however, most of the flowers possess *sepals* and *petals*, so that altogether there are four sets of organs. These are very often arranged in circles, and when all these sets or circles are present in any given flower it is said to be complete. The whole circle of sepals is termed the *calyx*. The petals taken altogether make the *corolla*; and calyx and corolla combined constitute the *perianth*. From the fact that the whole aim and object of the flower itself is ultimately to produce seed, and because this can only be done by the co-operation of the stamens and the pistils, these latter organs are frequently termed the essential organs of a flower.

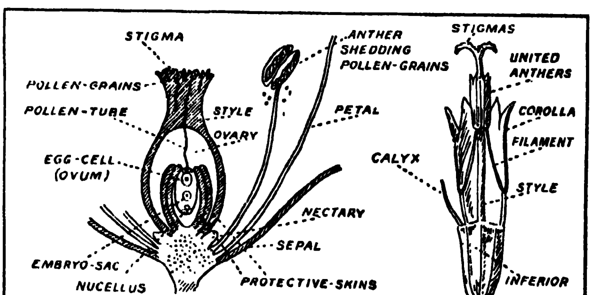
If we look at a plant with a view to observing where its flowers appear upon it, we shall find that they occupy, with great

regularity, one of two positions. They are either in what we have learned to call the *axil* of the leaves, or else they appear as *terminal* buds. This would point to the supposition that they are of a similar nature to leaf-buds, and further observation would suggest to us that sepals much resemble leaves. In fact, in some cases it is difficult to distinguish the two. If the reader will take the trouble to examine the next example of the white water-lily he sees, he will find that in this plant there is a wonderful series of intermediate stages between petals and stamens, and many other plants show transition effects also. So that the flower is practically a greatly modified and shortened branch, a conclusion we reach, first, because the flower-buds take the same mode of origin as the leaf-buds; secondly, because many intermediate stages are found in the organs of flowers; and, thirdly, for another reason not yet mentioned—namely, that in certain flowers the essential organs are found to be replaced by petals, or even green leaves.



THE PLAN OF A PATTERN FLOWER SHOWN IN LONGITUDINAL AND TRANSVERSE SECTION

Relationship between a flower and a leaf is further emphasised by the term *floral leaves*, frequently used to express all the organs directly or indirectly concerned in the process of fertilisation and in the production of the embryo, as opposed to the foliage leaves proper. These floral leaves include structures within which the germ-cell is formed, those in which the fertilising cells, called pollen grains, are formed, and, finally, those which bring these two sets of reproductive cells into such contact with each other that union takes place. The other floral leaves protect these.



A SIMPLE FLOWER AND SINGLE FLORET OF A DANDELION IN SECTION

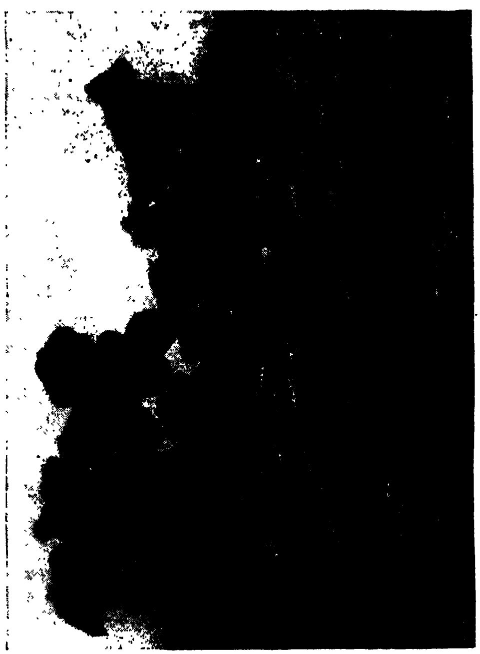
We understand now, therefore, that the last and uppermost floral leaves of a plant together constitute the flower; and the axis on which this is carried is termed the flower-stalk. This stalk may be a direct continuation of the original shoot, in which case the flower is called ***terminal***; but much more commonly it appears just above a leaf at one side, producing flowers which are *lateral*. Whatever the arrangement of the flowers may be on a plant, it is quite definite, and is termed an inflorescence. These various inflorescences, or arrangements of flowers on a stem, include the following kinds, amongst others: raceme, catkin, umbel, spike, capitulum, panicle, cyme, and so forth, all of which terms will be readily understood by a glance at the examples on page 3687, and which we need not further describe.

We have said that the calyx and the corolla together constitute the perianth, so that in the whole flower we may distinguish (a) perianth leaves (calyx and corolla), (b) stamens, (c) carpels.

The common arrangement of the leaves of the perianth is that of two whorls. The upper of these, which is the more delicate, is commonly distinguished by the fact that it may exhibit any and every variety of colour except the ordinary green of a leaf. This is the corolla. The lower whorl, which apparently consists of green leaves, is the calyx. Occasionally the two whorls look very similar. Next the stamens. These, too, are frequently arranged in whorls. Each stamen consists of two parts, an ***anther*** and a ***filament***. The anther is of supreme importance, because it is that part of the flower in which the pollen is developed. The filament merely supports the anther.

Like the perianth leaves and stamens, the carpels are arranged either in whorls or spirals. In one group of the flowering plants these carpels are like scales, and have their margins quite free and ununited. But in another section of flowers the carpels are so compressed together that their margins are completely fused, and when this is the case a capsule, called the *pistil*, is formed. This capsule is of very great importance, because it is a chamber which is really the *ovary*, and it contains the ovules, which are the rudimentary seeds. It also contains a slender stalk, or style, at the top of which there is a slight enlargement, or knob—the stigma. So that the pistil consists of ovary, style, and stigma (see diagram). We may regard the ovary itself as the sheathing portion of a leaf, the style corresponding to the stalk, and the stigma to the blade. It may also be mentioned here, to clear our ideas on the subject, that eventually the ovary will become transformed into the fruit capsule.

On account of their similarity and function to the eggs of animals, the little structures within the ovary have been termed *ovules*. After they have been fertilised they produce seeds. They stand in the same relation to the stem as the carpels do. In fact, they may be regarded as "the last uppermost leaves originating from the axis, subsequently becoming a constituent of the fruit."



POLLEN TUBES PENETRATING THE STIGMA

These pollen grains on the stigma of an evening primrose are seen emitting pollen tubes, which penetrate the tissues of the stigma down to the ovary, becoming many times longer than the diameter of the pollen grain from which they arise.

Each ovule itself consists of a nucleus surrounded by one or two coats, and the structure, termed the *placenta*, generally a stalk or filament, which connects the different parts. The style, as we have said, corresponds to the leaf-stalk, and the stigma to the blade of the leaf. The function of the stigma is to receive the pollen grains, and to maintain them in position; and since these are brought to the flower by such varying means and agencies as wind and insects, etc., we shall be prepared to find that the stigmas are of correspondingly great variety. In the plants which receive their pollen by the wind, the stigmas are expanded somewhat like feathers or brushes. In those which receive their pollen from visiting insects, the stigmas consist of knobs, or ridges, against which the insect knocks off its pollen in its movements on entering the flower.

It should also be mentioned before we leave these structural details that the stamens in some cases are quite distinct from each other; in other cases they cohere by their filaments into one or several groups. The same is true of the pistils, which are sometimes distinct from each other, as we see them in the buttercup, and sometimes united to form a compound pistil. In this latter case the union of the pistils results in a corresponding structure of the ovary, which is readily seen if such a cross-section be made of that organ as will show its compartments. A compound ovary shows several separate chambers, and in these chambers the ovules are carried in a very definite line, or position. That line, we have seen, is termed the *placenta*. Where the pistil is compound there will be as many placentas, or ovule-bearing lines, as there were pistils joined together. In this way we get different types of placentation according to the way in which the ovules are carried, and which are termed respectively parietal, central, and free central.

If all the parts of the same set or circle of organs in a flower are alike, the whole flower is then said to be regular, or symmetrical. Such flowers are those whose calyx, corolla, stamens, and carpels each contain the same number of parts, or a multiple of the smallest number. A flower like the stonecrop is termed symmetrical, it having five sepals, five petals, five carpels, and ten stamens; whereas the rose and the mignonette are irregular and unsymmetrical, because they have an indefinite number of stamens.

Lastly, in this connection, we must note the fact that there are certain flowers that, from the point of view of structure, are different in some of their parts. That is to say, in some flowers the stamens and the pistils are not found together in one, but in separate flowers, which are therefore said to be imperfect. Note carefully that this imperfection does not apply to the success with which the function of the flower is carried out, but merely means that both kinds of essential organs are not found in the same flower. For example, in the imperfect flower of the willow each flower of the catkin consists merely of a pistil, or group of stamens.

TRANSITION FORMS FROM PETALS TO STAMENS OF THE WHITE WATER-LILY

So much for the morphological aspect of the flower. The foregoing brief account of its structure will be sufficient for our purpose here, taken in conjunction with a careful study of the diagrams and illustrations appended. We may now turn our attention from the structure and position of these various floral organs to the functions which are allotted to them in the life-history of the plant, reserving for a later paragraph some special remark concerning pollen. The only two structures actually indispensable for the fertilising function of the flower are the ovules and the pollen grains. But it is quite obvious that these all-important structures must be also carefully and suitably protected in order that they may do their work. This protection must be given to them during the whole period of their development, as well as during the process of fertilising. It is not enough that ovules and pollen grains should merely be produced. Neither is it sufficient that, having been produced, they have some measure of protection; there must also be developed adequate means for bringing them together. This is attained by an exquisite adaptation in the form of the other floral leaves. In fact, we find on a careful examination of all the different parts of a complete flower that there is a very perfect division of labour among those parts, constituting another example of that specialisation of function we have studied in previous chapters in connection with different parts of the plant organisation.

Thus we find that sometimes only one part of a flower develops ovules, or pollen—one part secures protection, one part secures fertilisation. Sometimes there is a combination of duties allotted to a certain structure, as in those plants in which the carpels not only carry the ovules, but also protect them and convey the pollen to them. In others, such as the primulæ, the ovules are quite independent, surrounded by carpels which protect them, and secure pollen for their fertilisation. Many plants, several already seen, produce means of attraction for insects, which collect pollen from different flowers and scatter it upon stigmas ready to receive it. But whatever the arrangements may be, and however specialised or combined the functions may appear, all are adapted towards one end—namely, that of fertilisation, which is the whole object of the entire flower.

MALE AND FEMALE CATKINS OF THE ALDER TREE

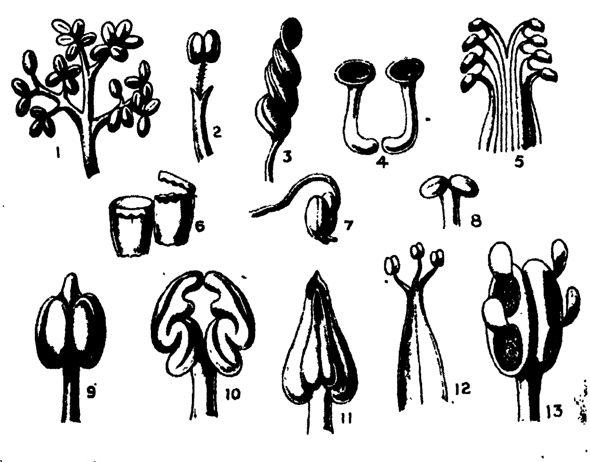
Pollen from the male catkins seen above fertilises the tiny female ones between them. The latter become woody cones, like the larger ones below, which have dispersed their seeds. Should these seeds alight in a stream they may spread the tree far and wide.

Fertilisation in a plant, as in an animal, consists in the union of the essential contents of two separate cells to form a new and distinct cell, from which latter the embryo of the new plant is

destined to spring. A cell from a pollen grain unites with an egg cell at a definite point, known as the apex of the embryo sac, as shown in our diagrammatic representation of the fertilisation of an ovule. The new cell which results, therefore, contains material derived from both the pollen cell and the egg cell, just as we have seen in our study of animal development that the embryo results from the union of male and female cell elements. In many plants the pollen, in order that it may succeed in its fertilising mission, must be produced by another plant of the same species—that is to say, from a plant other than that which has produced the ovules that have to be fertilised. The pollen grains themselves—which, as we shall see later, on page 3691, are of various shapes and sorts—are launched, by one or other of the means we have already studied, on the surface of the stigma; and, having been placed, or deposited, there, they proceed to grow in the shapes of tubes, usually taking some twenty-four hours or more before they begin to do this. The pollen tube so produced has to make its way through the *style* of the ovary, in which the ovules are lying, and this process of penetration will, of course, take a varying length of time, somewhat proportionate to the actual length of the style through which the penetration must take place. Sometimes this style is several inches long, and in such a case the descent of the pollen tube through it will be a matter of several days' performance. Such a case is seen in that of the crocus; but whether the time taken be long or short, the pollen tube eventually penetrates the ovule at an opening in the apex, and, growing inwards, ultimately reaches one of the cells within. Here, therefore, takes place the union between the generative cell of the pollen tube and the egg cell of the ovule. The union produces a fertilised germ cell, which, like other cells of this character, then begin to divide again and again, and thus to grow into an embryo. The process is very similar to that which we studied in the growing cells at the tip of the root.

ARRANGEMENTS OF FLOWERS ON THE STEM, SHOWING VARIOUS FORMS OF INFLORESCENCE

1, vervain, spike; 2, cherry, simple umbel; 3, groundsel, cyme; 4, cow-parsnip, compound umbel; 5, lilac, panicle; 6, Yucca gloriosa, panicle; 7, common marigold, capitulum; 8, currant, raceme; 9, Arum maculatum, spadix; 10, walnut, catkin; 11, scarlet pimpernel, solitary.



VARIOUS FORMS OF ANTHERS

1, Ricinus; 2, Aconitum napellus; 3, Erythræa centaurium; 4, Pinguicula vulgaris; 5, Polygala amara; 6, Garcinia morella; 7, Pyrola uniflora; 8, Caltha palustris; 9, Juglans regia; 10, Bryonia dioica; 11, Cyclamen europeum; 12, Corydalis capnoides; 13, Litsœa baueri.

It should be noted in passing that the two terms *pollination* and *fertilisation* are not necessarily synonymous. Fertilisation can only occur in flowering plants after pollination, or the dusting of the stigma with pollen, has taken place. But the important point to remember is that mere pollination does not

invariably mean that fertilisation must ensue. In spite of pollination taking place, sterility, or the absence of fruit production, may frequently occur, and this may happen for many reasons. The stigma may not be at the proper stage to receive the pollen. The pollen cells themselves may be unable to produce pollen tubes, and other factors may intervene.

In order that one ovule may be fertilised, it is only necessary that one pollen tube should reach it. But, owing to the risk that pollen runs of being lost in the process of transference from flower to flower, it is obviously necessary that many more pollen grains must be produced than there are ovules requiring fertilisation. The excess of pollen grains produced varies very much in different plants. In one variety of cereus there are no less than 250,000 pollen grains for some 30,000 ovules, or rather more than 8 to 1. In the common garden wistaria there are no less than 7000 pollen grains to every ovule, and a great many plants produce pollen grains in a proportion even many times greater than 7000 to 1. These differences obviously correspond with the manner in which the pollen is transferred from the stamens to the pistil, and the risks of loss involved in that process.

It must not be supposed, however, that any kind of pollen will fertilise all kinds of ovules. We must carefully remember that in this process of fertilisation in flowering plants we are dealing with living things, which are to all intents and purposes male and female, and which consist of more or less sharply defined classes, families, orders, and species. The possibilities of fertility and reproduction, therefore, are limited very much in the same way as they are in different species of animals, if not quite so strictly. One must suppose that under natural conditions, especially where many flowers and plants are growing in the same neighbourhood, or in great clusters, the pollen of many different plants will be deposited on one stigma by one or other of the agencies concerned in pollination. But unless the pollen deposited is of the character and relationship necessary, fertilisation will not follow.

In this connection one must not omit to mention a very curious and interesting fact with regard to pollination by insects—namely, that certain insects have been proved to show an extraordinary preference for visiting one single species of plant for quite a considerable time, especially if that plant is in the flowering stage, and in abundance in that district. The advantage of this process for insect fertilisation is, of course, obvious. At the same time, if one carefully observes the insects among the flowers, one will soon be convinced that most of them change the flowers visited frequently. Thus, "a bee which has just dusted itself with pollen in the flower of a winter aconite will fly across to visit a bush of *Salix daphnoides*, and as it passes a plant of *Daphne mezereum* it will suck its honey; a moment later it will swoop down to the flowers of *Crocus vernus* in the meadow near by, and then fly on to the sweet violet (*Viola adorata*). On the stigma of the last-mentioned plant will be found the pollen of all or several of the just-visited flowers, on the crocus that of the willow, and so on. The case is similar with wind-pollinated flowers."

In such a case the pollen of the willow

STAGES IN THE POLLINATION OF THE ARUM BERRY
The left-hand picture is a longitudinal section showing two tiny grains of pollen (enlarged in the centre picture) resting on the stigma. These grains emit pollen tubes similar to those seen on page 3085, which penetrate and fertilise the egg cells of the ovule in the centre. The right hand picture is a cross-section of some of the stamens, showing pollen grains developing within.

does not fertilise the ovule in the crocus. All that happens to the willow pollen is that it undergoes certain physical changes which are similar if it be placed in any moist material. Development, however, does not occur. In other words, the pollen tubes, if they grow, do not fertilise the ovules. Put this connection, if the pollen from the male flowers of a plant reaches, or be artificially placed upon, the mature stigma of the female flower of that same species, fertilisation is practically certain to follow.

The pollen itself, however, as we hinted in an earlier paragraph, deserves some

POLLEN GRAINS OF GRASSES CARRIED BY THE WIND TO THE STIGMAS OF THE FEMALE FLOWERS
The left-hand picture shows a branch of quake-grass whose stamens protrude through the scales of the spikelets of the flowers. The pollen shaken from the stamens is blown to the stigmas of distant plants of its own species. The right-hand picture shows stigmas of cocksfoot grass receiving pollen grains blown to it by the wind. The latter picture is highly magnified.

in another way, one may say that it is part of the function of the stigma in a flower to exercise a capacity of selection of the proper kind of pollen suitable for its own ovule fertilisation. How this selection actually is brought about we do not know.

Numbers of experiments have been made upon the point, but all that we can say is that with certain pollen applied to certain stigmas fertilisation does, or does not, take place; or that with such and such pollen no seed formation follows, or moderate production of seed follows, or great abundance. In fact, all the observations and experiments which have been directed towards ascertaining the general laws which underlie this process have led botanists to conclude that when the pollen from one species of plant reaches, or is put upon, the stigma of another species, such pollen grains produce tubes capable of fertilising the ovules only when the two species of plant concerned belong to the same natural family of plants. Conversely, pollination between two individuals of different natural orders of plants usually is not followed by fertilisation. Finally, in special mention. It is a wonderfully interesting substance, exhibiting many astonishing variations when subjected to careful examination. In many of the flowers which are not at all conspicuous to the eye the pollen is in the form of a fine, dry powder. This is the case in the family of grasses and rushes, and sedges and conifers. In the more elaborately coloured flowers the pollen is frequently of a sticky nature. The grains themselves, too, differ extremely in both size and colour, as well as in their consistence. Some are long and green, some long and yellow, some as broad as long. A very common shape is a somewhat oval grain rather like the shape of a grain of wheat. Our illustrations indicate the various shapes and appearances of a number of pollen grains from a number of species of plants.

Each pollen grain is chiefly made up of a cell covered by a thick outer wall and a thinner inner wall. Within these is contained the protoplasm of the cell itself, and amongst this is frequently found some grains of starch and minute oil globules. On the outer surface of the grain may be

seen one or two protuberances, which indicate the position where the inner coat will ultimately emerge through the outer one in the form of the pollen tube. The whole grain, in perhaps quite half of all the flowering plants, is ellipsoid in shape. Others are round; others lancet-shaped; others biscuit-shaped; others angular; others three-sided, four-sided, five-sided, or six-sided; others cubical.

The surface of the pollen grain, especially in the ellipsoid and round grains, is generally grooved or marked, and the number of grooves upon the surface is found to be the same in all grains from the same species of plants. In some pollen grains there may be found very small openings in which a yellowish oil is contained. Many species of pollen have such an oily substance over their whole surface. Others stick together by means of an entirely different viscid material, such as is found in the pollen grains of the fuchsias and orchids, in which it can be drawn out into threads.

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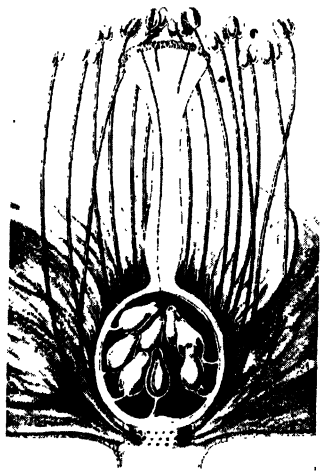
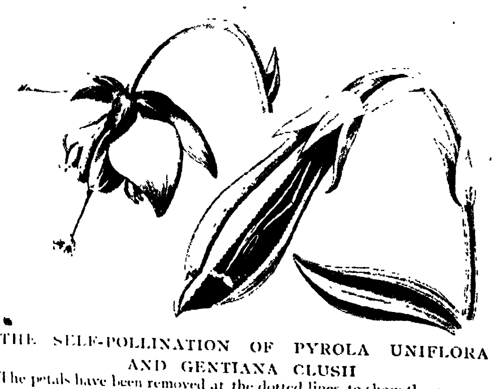
There are other structural peculiarities and appearances in pollen grains, but the above will suffice to mention here; and the point now arises, Why all this variety in the formation of pollen grains? What is the object of all the grooves and furrows and projections, and oil and apertures, and so forth? We can only answer some of these points in a sentence or two here.

When pollen is placed in water, it swells up quickly. Its inner wall must therefore be able to stretch with ease. The folds allow the fluid to pass quickly to the interior, and the grooves become inflated. The pollen grains, so thoroughly moistened, may be several times the original size. All the various inequalities and irregularities on the wall of the pollen grains enable a number of grains to cling together. In this manner an insect is able to transfer large masses of pollen at the same time. The dry pollen of the grasses and other plants—dusty pollen, as it is sometimes called—does not cohere in this way, and so cannot stick so easily. On the other hand, its consistence renders it peculiarly susceptible to the distribution by wind. The capacity of pollen grains to stick together, so that they may easily attach themselves to the hairs, legs, etc., of insects, is of very great importance. The oily and viscid coating of other pollen grains aids in a similar manner.



A PICTURE-DIAGRAM OF THE FERTILISATION OF AN OVULE

Lastly, we must briefly refer to self-pollination. In the simplest form, when the flower opens the stigma is seen in front of the entrance, and already ripe, while the anthers adhere to it, but are closed. At this stage cross-pollination can be brought about. But a little later in the flowering time the anthers next to the stigma open, and the stigma itself is, of course, at once covered by pollen which is set free from them. Many cases of self-pollination, however, are much more complicated than this. Some are brought about in pendent flowers by the pollen from the anthers falling upon the viscid stigma, as happens in the snowdrops. In many cases the stamens are particularly adapted for the process of self-pollination by the manner of their bending, or by their peculiar movements, as is seen particularly in the stamens which curve inwards. Sometimes self-pollination is brought about by a peculiar bending of the pistil, sometimes by a coiling arrangement of the stamens and the pistil, and sometimes actually by means of the corolla. This latter is seen in those flowers whose petals are cup-shaped, and in which the anthers adhere to the inner surface of the petals, coming in contact with the stigma when the corolla closes.



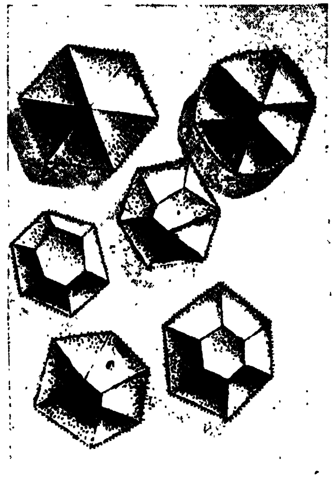
THE SELF-POLLINATION OF PYROLA UNIFLORA AND GENTIANA CLUSII

The petals have been removed at the dotted lines to show the process

THE VARYING FORMS OF POLLEN GRAINS

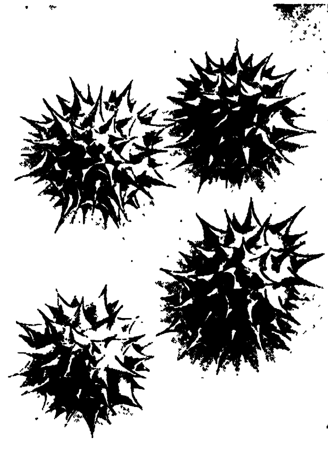
RHODODENDRON

PASSIFLORA CŒRULEA

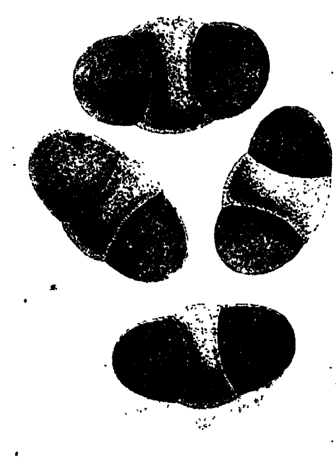


DANDELION

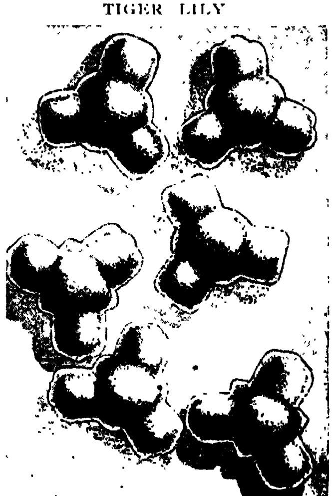
TIGER LILY



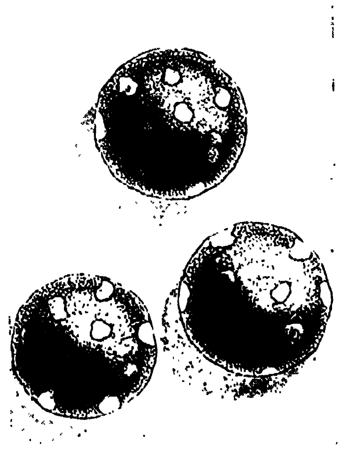
MARGUERITE



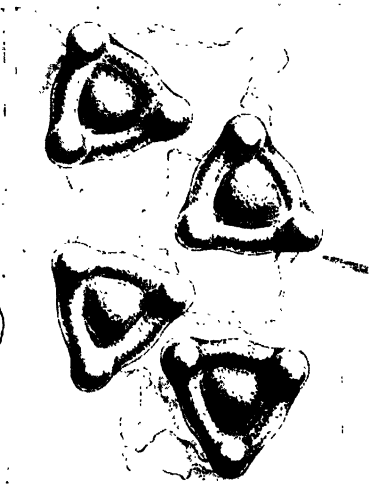
SCOTCH PINE



CLARKIA ELEGANS



PHLOX

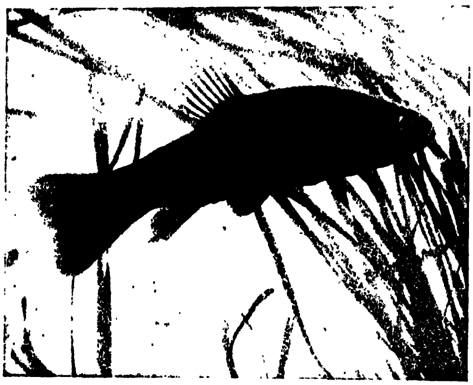


EPILOBIUM AUGUSTIFOLIUM

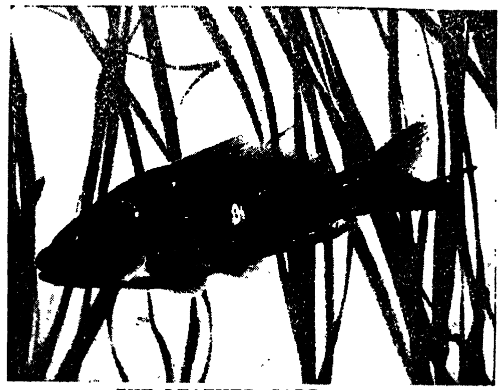
FAMILIAR FISHES OF INLAND WATERS

THE CHUB

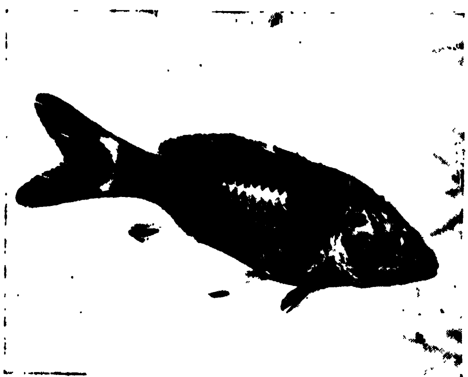
THE COMMON CARP



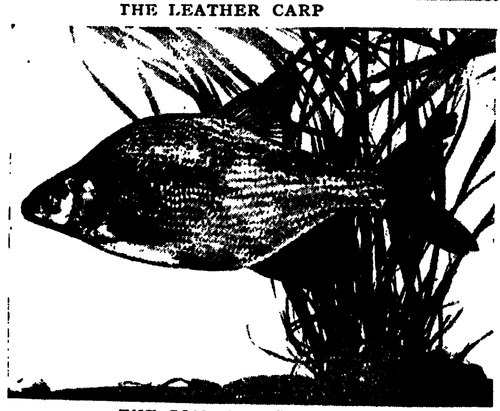
THE TENCH



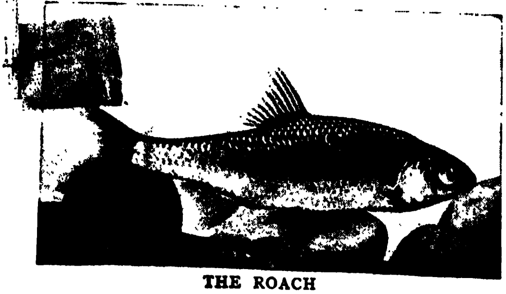
THE LEATHER CARP



THE VARIEGATED GOLDFISH



THE COMMON BREAM



THE ROACH

THE COMMON RUDD

These photographs and others on these pages are by W. B. and S. C. Johnson

ROMANCE IN THE RIVERS

Mysterious Habits of the Fresh-Water Fish Which Serve Man as Food

SALMON, TROUT, STURGEON, PIKE, AND EELS

THE naturalist is not driven to sea in quest of mysteries in fish-life. He may crave of Fate, as Swift craved,

A river at my garden's end,

and, that granted, he need go no more sea-roaming. Mysteries will come by him, leaping, gliding, racing through the clear waters—problems as challenging as any pertaining to the life of the ocean. There is not a fish that swims our streams as to which the last word has been written. None other has received so much attention as the salmon and its tribe, yet these have succeeded in puzzling naturalist after naturalist, and more than one good man is remembered by the errors concerning it to which he stood committed at the end of a life of investigation. Even today, carefully as the life-story of the salmon has been worked out, we do not know the whole; there are points which still need clearing up. We are more fortunate at last with that long-standing mystery the eel, although we have had to go to sea to find the key to the riddle. But our inland waters have their other secrets, and no man need regard the subject as exhausted. He may, if he will, still find work in the matter of classification as regards the salmon tribe, a point as to which experts even yet are not all of the same way of thinking. For present purposes, however, the life-story of some of this famous family will be of greater interest than an excursion into the domain of classification and origin.

The salmon, we say, is a sea-fish which resorts to fresh water for the breeding season. For the moment we leave it at that, with a reservation—salmon ascend rivers not at breeding time. Taking British salmon rivers, the spawning season is from October to January, both inclusive, and as the time draws near the fish begin to troop in from the sea. They make the transition from salt water to fresh without any preliminary, though salt water is absolutely fatal to their ova. There is a limit to the powers of the salmon as a leaper, so that streams with falls and obstructions too precipitous in character lack salmon. As everyone who has seen a salmon-ladder knows, the fish can ascend considerable heights when thus assisted. Under natural conditions rocky heights which afford successive leaps can be negotiated, but a leap of six feet seems to be the limit of the salmon's aerial performances. Once they quit the sea the salmon appear to desire only the source of the river. They make their way upwards and onwards until they reach clear, shallow water running over a good gravelly bed. Here the female, attended by her lord and his rivals, makes what may be termed a rough-and-ready kind of nest. It is really a trough in the gravel, hollowed out by the action of her body. Here she deposits her eggs, not all at one time, but day after day. Each batch is fertilised by the male, and each, after fertilisation, is, bar accident, covered with gravel. The number of ova depends upon the size and condition of the salmon, but Buckland's calculation is universally accepted—about a thousand eggs for every pound weight of the fish. When the eggs have been laid and fertilised, the kelts—such being the name given to salmon which have spawned—turn about and retreat to the sea.

The fish which turn again to the sea are hardly recognisable as salmon. When they quit the sea for the river they are the picture of beauty. But as they ascend they lose their silvery hue, and a dull coppery red takes its place. The body becomes distended and slimy, and the male develops an extraordinary hooked beak to the lower jaw. A not very ancient belief was that this development was to serve for

digging the trench for the eggs, and also as a weapon of offence and defence. But the female, as we have seen, makes the trench, and she, except when advanced in years, does not show this abnormality. The beak is certainly not a weapon of offence. It is cartilaginous in composition, and really prevents the salmon from opening its jaws to any appreciable extent. In this sense the beak may possibly be regarded as a kind of defensive weapon. The salmon as it runs up the river becomes so fierce when in opposition to other males that, in the restricted area in which the ova are actually deposited, battle with unhampered natural weapons would end most seriously for the whole family. As two queen bees, finding themselves in a position to inflict mutually

A SALMON LEAPING UPSTREAM

fatal blows, cease their combat in order that the hive shall not be left queenless, so, perhaps, male salmon are fashioned to fight with blank cartridges, so to speak. Fatal conflicts do occur, as it is, where the larger fish are challenged by smaller, but not to anything like the [illegible] which would inevitably be the case [illegible] all free, in the narrow limits of the spawning grounds, to wage war as they [illegible] the wide sea.

The spawning season may keep the salmon four or five months from the sea. Now, in that time they do not feed! Instantly the thought comes to mind—how is it, if they do not take food in the rivers, that the angler catches them there by means of rod and line? The reason is, apparently, that the garish fly of the angler arouses the curiosity, rather than the appetite, of the salmon. Or it may be that the lure represents a possible luxury which may stimulate a momentary craving. Everyone who has kept fish in pond or lake is aware that fish which are well fed and have food available exhibit curiosity; that they will critically examine and "mouth" a leaf, a blossom, or other object which arouses their interest. Possibly the case is the same with salmon in the river. Be that as it may, the best opinion is that salmon, when ascending or descending from the spawning grounds, do *not* feed, and that the stories of their devouring the young of their own kind which accompany them down-stream are based upon inaccurate observation. A salmon caught in the sea may contain five or six herrings—more than a man could eat at a meal. But the river salmon—that is, the fish travelling to or from the spawning grounds—is practically hardly ever known to contain food.

It is common knowledge that many fish abstain from food at spawning time, but the long fast of the salmon is exceptional. The salmon fasts during a long period of extreme physical stress. The ova of the female develop and mature in that time, and the male attains its highest pitch of physical activity. Nor is the mystery wholly ended here. It is not at spawning time alone that the salmon enters the river. In certain rivers they run at various times throughout the summer. Why they should

leave the sea in which their livelihood lies no man can explain. One theory is that they become surfeited with food, and that they voluntarily subject themselves to a sort of disciplinary fast, such as that imposed one day in seven upon the lions at the Zoo. Another, and of course it is a mere guess, is that possibly these river-born fish sometimes thirst for the fresh waters in which they were cradled. There is a third possibility, to be advanced only with the utmost diffidence. In the sea the salmon becomes infested with a certain species of sea-lice. These are unable to exist in fresh water. Salmon, when they first enter a river, are generally found to carry a number of these parasites, of which they are gradually relieved as they make their way to the higher reaches. Is it possible that instinct at times impels the salmon to seek fresh water in order to gain freedom from its tormentors? If it can fast for four or five months at a time when the spawning season approaches, it is not impossible that it might willingly undertake a self-denying ordinance for the purpose of ridding itself of parasites which must, one would think, be to some extent inimical to the full development of the fish.

That matter of development in the sea is an interesting one. Increase of weight varies, of course, with the individual fish, and with the food supply to which it finds its way. Mr. Calderwood, of the Fishery Board for Scotland, has at various times published tables on the subject. Perhaps the most remarkable example of rapid growth is that of a smolt, which, liberated when weighing only an ounce, turned the scale at $3\frac{1}{2}$ pounds when recaptured fourteen months later, an increase of 5600 per cent. for the period. Scarcely less striking, however, is the evidence from a Ness salmon which, weighing 8 pounds, and measuring 35 inches when taken out and marked, was found, six months later, to have increased its weight to 23 pounds and its length to 38 inches. Even that is eclipsed, however, by the feat of a sea-trout marked and put into the water at Coquet, in Northumberland. When taken out of the water at Aberdeen forty-nine days later, it was found to have doubled its weight, but without any addition to its length.

THE QUINNAT SALMON OF BRITISH COLUMBIA THAT SUPPLY THE CANNING INDUSTRY

We must return, however, to the ova which the adult salmon have deposited at the river-head. These are exposed to many

dangers from predaceous fish and birds. Frost will not hurt them any more than it hurts the bud upon a hardy tree, but the ice formed over shallow water may, upon breaking up, carry away masses of soil in which the ova are laid. Cold retards hatching, so that there may be a difference of four months between the appearance of the infant salmon from two batches of eggs deposited in the same week. Thus in warm waters the eggs may hatch in as few as thirty days, while in extreme cold the period of incubation may extend over fully five months. The larva, which is first known as an alevin, emerges from the egg with a sac attached, containing the residue of the yolk of the egg, and this constitutes its food supply for the first few days, or even weeks, of its life. With the absorption of this, the tiny alevin assumes the form of a fish rather more than an inch in length, and is known as a salmon parr. The minute insect life of its native stream suffices to keep the little alevin going for the first year, it may even be the first two years, of its career; but then the sea begins to call, and, like migrating birds, the little fish set out for the place whence their parents came. They have now entered upon the smolt stage, and are still quite insignificant in size and weight. It is a striking fact, however, not without parallel, of course, in natural history, that even while thus physically immature, the young male samlet may be capable of rendering the eggs of the female fertile. But seaward now is the aim of the teeming myriads of smolts. They are not so many as those that hatched. Birds and fish, and perhaps an otter or two, have been busily at work, and those which survive are probably the most elusive as well as most fortunate. In the sea the smolts find abundance of food—shrimps, prawns, the fry of herrings and other fish. It is still generally believed that the ruddy hue of the salmon's flesh is due to the pigment of its crustacean diet, but as the adult salmon subsists mainly upon herring, haddock, and the like, yet retains its characteristic flesh-tint, the effect is obviously attributed to the wrong cause. The young salmon may stay one year or two in the sea, feeding

THE TROUT

THE VORACIOUS PIKE

and rioting amid scenes of plenty, then they renew their riparian life, impelled by—surfeit, thirst, home-sickness, parasites, sexual impulse? They are now grilse, and as grilse they return to the sea, should their visit not be related to the spawning season. But if nursery cares have called them from the deep, then it is as kelts that, upon their downward journey, they are known. The changeful succession of stages has now been completed—alevin, parr, smolt, grilse, kelt, and there remain only alternations between sea and river, with increase of bulk in the individual, and increase of kind.

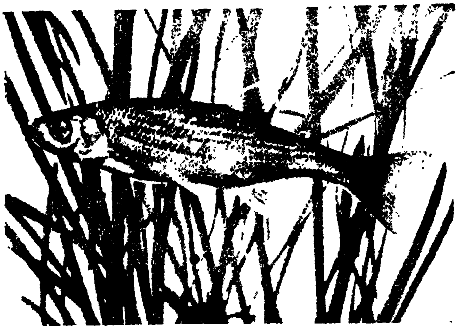
As a rule, salmon return to the rivers in which they were hatched, but the retaking of marked fish shows that the rule has many exceptions. Possibly the supposed predilection for native waters has really a geographical explanation. The outgoing salmon do not find it necessary to travel far from the point of the coast at which they emerge; hence, by taking the river-mouth nearest at the proper time, they naturally find their way to the head of the stream in which they were hatched. Of course, full many a salmon is born to end its days without ever returning to the site of its cradle.

There be many dragons in the path of the juvenile salmon, and the sea, too, has manifold perils. The product of ova artificially hatched and protected have, it is fair to assume, a better chance of life in the early stages than those exposed to the unwarded dangers of the river; but it is estimated that of every thousand larvæ released from the hatchery only three return as mature salmon. In a couple of recent years 10,000,000 salmon fry were liberated from eighteen hatcheries in Ireland, and these, on the foregoing calculation, should return 300,000 adult salmon to the Irish rivers concerned. The result seems disproportionately meagre, but when we realise that, as stated, each female salmon produces a thousand ova for every pound of her weight, the possibilities of increase become infinite.

British waters show nothing like the results obtainable from some Asian and American rivers, where streams become absolutely choked with spawning fish. An interesting census was taken in 1909 at a salmon run in Wood River, Alaska, where one of the canning companies constructed for the purpose a gateway and tunnel, through which the fish were compelled to swim on their way upward. This admitted of their being counted, for a time, one by one. The first 84,000 were separately enumerated, but when the fish began to troop by, 250 to the minute, the strain became excessive, and thereafter an average was struck, and a count taken for one minute of each quarter-hour. The total counted, from June 14 to August 10, was 2,600,000 salmon. These figures are exceeded in the greater salmon rivers; but they will serve to set that man dreaming who

THE STRANGE LAMPREY THAT WAS LONG REGARDED AS A FISH

rents a Scottish salmon fishing, and, in spite of legends as to 5000 fish having been taken by a single rod in a season on the Aberdeenshire Dee, finds his



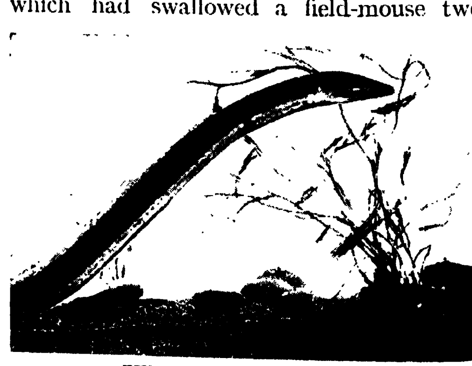
THE BLEAK

salmon cost him from £5 to £10 apiece.

Perhaps the figures from Wood River may some day be challenged by the waters of New Zealand. Many abortive attempts have been made to introduce the salmon into Antipodean rivers, but whereas trout, like the red deer and the foxes, become giants, salmon proper long failed to realise expectations. But in 1909 complete success was attained with one or two cargoes of ova. Half a million Scots and Irish ova, followed by as many from English streams and the Rhine, were successfully transported. The losses sustained were astonishingly small. Of the first cargo only 5 per cent. of the whole were lost; 7 per cent. of deaths were reported as to the German ova; only a trifle over 1 per cent of the English. And these ova, after being carried in a refrigerator half-way round the world, and handled again and again, began hatching out within a few hours of being placed on the hatching-trays in New Zealand. Antipodean readers will find a pathetic interest in the fact that it was while engaged, during terrible weather, collecting salmon ova for New Zealand, thirty-and-odd years ago, that our incomparable Frank Buckland contracted the disease which brought him to an untimely grave.

In many respects the trout, as to certain of its species, resembles the salmon in habits. Notably is this the case with regard to sea-trout, or salmon-trout, a fish which descends to the sea to feed, and makes the river its breeding ground. All trout, save those confined to lakes, are migratory, and even these latter, if they are to multiply, must have access at spawning time to a stream, naturally or artificially furnished. High opinion holds that the sea-trout, the migratory river-trout, and the various lake-trout are all varieties of one race. The famous Loch Leven trout is regarded as marking the transitional type between sea-trout and river-trout. Sea-trout have been landed weighing nearly 30 pounds, and now and again common trout have been brought to scale to show figures almost as surprising. These are, of course, exceptional weights, and the trout of from a pound to a pound and a half is ample enough to be the hero of many an angler's story. Trout kept in lakes and regularly fed seldom attain more than about 10 pounds, even though they may live as long as fifty years. The voracity of the trout is not as a rule emphasised, writers preferring to reserve the term for the pike. But the great lake-trout certainly runs the pike close in the matter of appetite and capacity of swallow. And even the common trout refuses to strain at trifles. One was caught during the past summer which had swallowed a field-mouse two

THE PERCH



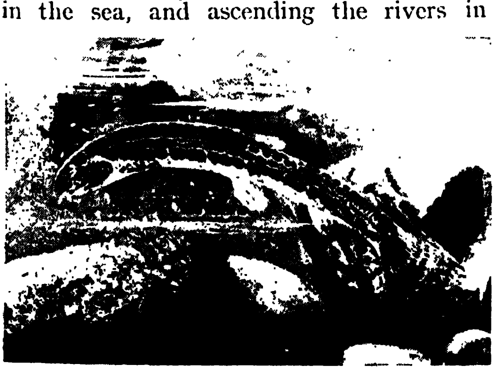
THE BLUNT-NOSED EEL

and a half inches in length; another, when hooked, revealed the presence in its gullet of a young viper, which the fish had bitten into three pieces. Trout are more

conformable than their friends quite realise. Given plenty of water, they can live in conditions which would be thought impossible. The record of the kind was achieved by a trout whose remains are still honoured at Inverness. Landed at Milburn, by a railway man, it escaped the frying-pan, was kept alive in a bucket of water, and then transferred—to the tank of its captor's locomotive engine! For ten years that trout was the greatest traveller in the whole order to which it belonged. It, willy nilly, outdid the feats of Mary's little lamb, accompanying its owner on all his journeys. Man and fish became the best of friends, so that it would swim to the end of the tank to be fed from the driver's hand while the train was on its travels, and when a pail was dropped into the water it would fearlessly flop in. Occasionally the man would bucket his friend home with him, and it was one of these reunions which brought dissolution. A box of matches was dropped into the bucket, with fatal result to the trout. During its career the trout travelled in the tanks of three different engines, and flourished during journeys aggregating many thousands of miles.

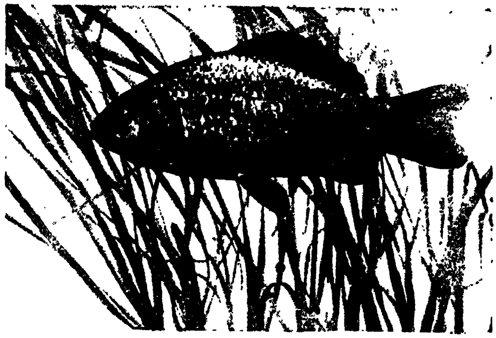
THE SILVER BREAM

The charr, which are locally known as fresh-water herring and as whiting, are another of the salmonoid groups, passing the summer in the sea, and ascending the rivers in



THE LOACH

winter to spawn. British supplies have been reinforced by the successful introduction of the excellent North American charr, and another ally, the hucho, from the Danube. The smelt, regarded as the connecting link between the true salmon and its allies, thrives best in the sea, but its smaller kind are healthy and prosperous in



THE PRUSSIAN CARP

the rivers and lakes to which they make their way. The smelt, by the way, has a curious ally in the candlefish, famous for the oily nature of its flesh, which can be lighted and used as a candle, although it is distinctly a food-fish. Other well-known salmon-like forms are the coregonoid group, which includes the gwyniad of Bala Lake, the closely allied or identical powan of the Lake District, the vendace of Lochmaben, and the pollan of the Irish lakes. They are interesting and peculiar as the only British fresh-water fish which cannot be taken with rod and line. The grayling, beloved of the angler when it is in condition, but detested when it takes the bait cast for salmon or trout, differs from the rest of its tribe by spawning, not in winter, but with the coarse fish in April and May.

The sturgeon tribe, to which we now pass, has for many centuries been rarely represented in British waters; hence, like the whale, it was long ago proclaimed a royal perquisite. The sturgeon in question is the true sturgeon. There are several divisions of these fish, which are typical ganoids, or bony armoured, as are the bony pike and the bow-fin, which constitute separate sub-orders of the same order. The sturgeons are an ancient type of fish, armed with a bony covering, as all fish were once armed. Included in the order are the

large spoonbill sturgeons of the Mississippi, whose flesh is smoked and roe sold as imitation caviare; the sword-bill sturgeon of the great Chinese rivers; the toothless sturgeons, and other genera. The family of toothless sturgeons, of which the true sturgeons constitute a genus, are of immense importance to the Danube, the Volga, and other European rivers. They are sought for their flesh and for their air-bladders, from which isinglass is made, but chiefly, of course, for the roe of the female, which constitutes caviare. Commonly growing to ten feet, and capable of twice that size, the sturgeon is extremely prolific, the adult female producing three million eggs in the course of a single season. It is this remarkable fecundity that has kept the sturgeon in existence, for no fish is more persecuted by man. When we read of 15,000 sturgeon being taken in the course of a day at a single fishing-station on the Volga, we can readily believe that a river 400 feet in width and 25 feet deep has been known to become completely blocked by a solid mass of these fish.

The Pirate Fish of the River, Lake, and Pond

The habits of sturgeon seem to vary with their habitat. Although they must all quit the sea to spawn, in some rivers they appear not to return to their native haunts until full grown, while other rivers attract sturgeon of all ages. Some species of sturgeon in the Danube reach a length of 24 feet and a weight of half a ton.

Jumping the chasm which divides the sturgeon from the pike, we come next to this pirate of the river, the lake, and the pond. Pike are widely distributed throughout the majority of rivers of the three northern continents. They are long-lived fish, and attain great size and bulk, specimens having been caught measuring 35 inches and up to 50 pounds weight. This, however, is the exceptional fish, for a list published in the "Field" some time ago showed nothing heavier than 38 pounds. Even that is a considerable fish when it is remembered that the food supply of our British rivers is necessarily limited. But the pike is no finicking epicure. He eats anything, from his own kin to rats and waterfowl. He lies like a log in the water, with whose weeds and shadows his colouring perfectly harmonises, and then at the right moment makes one terrific dash, and there is an end of his victim. Armed with terrible teeth, one series of which are recurved and hinged like those of the snake, the pike's mouth is a death-trap from which there is no escape. The victim must go forward down its captor's throat; the action of the collapsible teeth makes this inevitable.

Pike are very destructive in salmon and trout streams, and as they are prolific —an adult female lays nearly 600,000 eggs—the number of fish they consume is enormous. The well-armed stickleback, whose prickles are commonly proof against the teeth of the greater fish, appears to be the only little creature to which Nature has granted a charter of emancipation from the terrors of pike-infested streams, and the perch manages to hold its own.

The Most Domestic of the Fishes—the Coloured Carp

We must pass over other well-known fresh-water fish, such as the bream, the bleak, the barbel, and the gudgeon, and come next to the carps, of which we have, in various parts of the world, over a hundred genera, divided into two sub-families. The common carp, now a well-established fish in European waters, was brought to Europe from China, where it has long been domesticated. Under favourable conditions the carp attains great age, fish of 25 pounds and upwards and a yard in length having been hooked. The popular goldfish is, of course, a carp which has been brought from Asia to the West. Like the common carp, it survives extremes of temperature. The same species of fish which you see in the tanks of the tropical houses at Kew or of the orchid growers will winter without difficulty in water which becomes coated with ice. Those of us who care for our goldfish break the ice and keep the fish well supplied with food, but they can dispense with this attention.

How to Keep Captive Fish Free from Fungus

The difficulty of keeping this fish free from fungus in captivity is a problem which all of us have had to face. Many experiments have been tried, and success seems at last to have been achieved at Kew and in St. James's Park, where a weak solution of copper sulphate—one part in 5,000,000—was successfully tried for the eradication of the green and brown algæ, which render such waters offensive and unwholesome. The cure for the algæ proved also a cure for the fungus on the fish, which, previously badly attacked by this parasite, were afterwards found to be wholly free from it.

Our chapter must close with the story of the eels. There are very few stretches of fresh water which do not harbour these fish;

ELEGANCE AND BEAUTY FROM THE WATERS

THE JAPANESE VARIETY OF THE GOLDEN CARP, PHOTOGRAPHED IN AN AQUARIUM

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there is no tidal river which does not bear its prodigious harvest every year of young eels, or elvers, coming up from the sea. We find eels in wells, in running streams, in ditches and dykes; we find them in field-ponds far from rivers. It was impossible to account for their presence unless they had been blown there as are little fishes and little frogs caught up from some hurricane-swept water-surface, and carried afar, to spread consternation among superstitious natives. The young of the eels were met at sea, but they were regarded as a distinct genus of fish, and were given the name of leptocephali, while no one knew how the big eels at home perpetuated their species. The story is out at last. The huge eels which are known to have spent many years in ponds, tanks, and wells are the bachelors and spinsters. Those that vanish and are seen going down-stream to the sea are the potential progenitors of the generations to be. It would seem that some eels, though they may attain great age and bodily bulk, do not attain sexual maturity; they remain in their ponds. Others, of course, may find it impossible to escape from the prison in which they have incarcerated themselves. But when sexual impulses impel the adult eel which is in such a position that it may escape to the sea, to the sea the eel goes. Eels spawn in the ocean abysses, and die. The adult never returns to the fresh water from which it set out. A mature female eel may produce over ten million ova. The production and fertilisation of these vast numbers exhaust the vitality of the adults, and they expire at the end of the spawning season. The larvæ undergo a remarkable series of metamorphoses. The familiar transparent outline of the little fish, with sharp-snouted head, which earned a distinct name, gradually yields place to the cylindrical form of the elver. It is believed that these changes take a year, and that at the end of that time the tiny mites of life set out for the rivers. They are equipped with specially modified gills, which gills retain moisture, and enable them to accomplish journeys over land fully as remarkable as those of the climbing perch. They climb lock-gates; they worm their way through sluices and pipes, and all manner of mechanical obstructions; they take to the land, and wriggle like tiny snakes across the dewy grass, to where instinct tells them water is to be found. That is the manner in which isolated ponds and water-holes get their eel supply. The damage done by eels to the rest of the fish-life of our rivers is inestimable. Not only do they attack little fish and big; they consume enormous numbers of ova. They do not limit themelves to a fish diet, but are omnivorous.


THREE-SPINED STICKLEBACKS WITH THEIR YOUNG

Our common eels are related to the savage murænas, of which some fourscore species are distributed over all tropical and temperate seas and the mouths of certain tidal rivers. The conger, too, of which upwards of 70,000 cwt., valued at about £50,000, are caught annually in British waters, are—like the deep-sea eels, which flourish at depths of from 1200 to 12,000 feet—related genera. An interesting eel is the so-called amphibious eel of Bengal, in which there is an accessory breathing-sac, enabling the eel to breathe atmospheric air. This eel, by the way, has either put on scales or neglected to cast them aside. The remainder of the tribe are smooth-skinned and slimy, as is within the knowledge of everyone who has tried to pick them up with ungloved hands. There we must leave the fishes. The sketch is incomplete, but it may serve to point a track along which the student may find the whole wide subject accessible and interesting, and lure him to investigations both beside running and quiet waters.

WHERE CHARACTER BECAME SUBLIME

A meeting of the men and women of Eyam, Derbyshire, where, with a self-control bordering on the sublime, the whole community resolved to confine themselves within the bounds of their own plague-stricken village. This occurred in June, 1666; and in October, when the plague was stayed, 259 inhabitants out of 300 had died.

WILL AND SELF-CONTROL

What are the Teachings of Science and Experience on the Vexed Question of the Freedom of the Will?

THE SIGNIFICANCE OF SELF-RESPECT

OUR study of behaviour, from the humblest and simplest reflex actions, if they are indeed worthy of the name of behaviour, up to the exhibitions of instinct and temperament, has hitherto had nothing to say of a very great fact of man, which we know, or seem to know, in ourselves and others, and which we call the Will. In the latter part of the nineteenth century, indeed, it seemed to many students that the Will was something of a myth, which might do for poetry and popular speech, but must be banished from science. The tendency was natural. Physiology showed, beyond dispute, how many things are done in us which *we* do not do. They happen to us, in us, for us, but *we* certainly cannot be said to have initiated or willed them. In many instances we should be very badly off indeed if these acts, such as the beating of the heart and the acts of respiration, required our volition. Large spheres of bodily activity are found to proceed automatically, quasi-mechanically. So far are men from initiating them that only yesterday or the day before was the existence of many of them known. More and more we see how true it is to regard the body as something which responds rather than initiates; and when we study response in detail we find that much of it can be described without any reference to the Will at all. It is just "reflex action," perhaps simple, like the falling of the eyelids when a fist approaches the eye, or complex, like the behaviour of instinct, which Herbert Spencer defined as "compound reflex action."

Already physiology had taken from the sphere of Will a host of actions about which there could be no doubt, and then the developments of the evolutionary psychology came and took from the sphere of Will a number of actions which do indeed feel, at any rate sometimes, as if we willed them, but which, nevertheless, can be proved to owe their origin to levels of being below the Ego, and immeasurably older. Half our exhibitions of anger and desire, of tenderness and fear and wonder, cannot really be described as volitional, or willed at all. And, having come so far, the tendency of many was to conclude that, on further examination, the Will would be found to have no sphere at all. Every act and intent and piece of conduct, internal or external, could be explained in terms which, at the most, need never amount to more than delayed, modified, and complicated reflex action.

It has long seemed clear to a certain number of students, however, especially those who have approached psychology from below, through the levels of physiology, that not only does the sphere of Will remain, but our modern knowledge of the nervous systems is the best testimony to its reality. By a kind of paradox, we find the Will just when and where its existence seems to be superfluous, or even disproved. The newer theory of the Will, which finds its true realm and power in the control of action, or the permission of action, rather than in its initiation, has received much attention during the last decade.

Directly we study the behaviour of any but the very humblest organisms, we observe that not only do they act for purposes, but sometimes they refrain from action, also for purposes. The process by which action is arrested, delayed, minimised, controlled, is technically known as inhibition, and it is certainly one of the most important of all facts in physiology and psychology. Instead of the almost mechanical process by which a stimulus produces an inward current in a sensory or

afferent nerve, and a response takes place by means of the corresponding motor or efferent nerve, we find the intervention of something from some higher (and later) part of the organism, which says "I forbid," and the customary response does not occur. Every step upwards from immediate and unvarying response to whatever impressions are made upon the sense organs, towards the plane of behaviour in which a man stands ruled from within, master of himself, "four-square to all the winds that blow," necessarily depends upon the development, in increasing power and delicacy and discrimination, of the function of inhibition.

The Oldest Level of the Nervous System a Machinery of Response

Let us now remind ourselves of that view of the structure and function of the nervous system which we owe to the late Dr. Hughlings Jackson, and which underlies all modern theories of behaviour. He showed that, in man and the higher animals, the nervous system is composed of levels, which we may reckon as on the whole three in number, that these levels are superposed, the lowest being the oldest, and highest the newest, whether in the development of the individual or the evolution of the race, and that the middle level is master of the lowest, and the highest master of the other two. Control is the essence of the arrangement. The lowest and oldest level exists for sensation and response, and, so far as itself is concerned, its business is to make responses, of various kinds, *then and there.* Except for the influence of habits, which will probably make the response a trifle quicker, or, in other cases, a trifle slower, the apparatus is invariable so long as it is in proper order. Its business is "not to reason why," but to do what it was made for.

The Newer Nervous Level a System of Control

If this was all the nervous machinery we had, then, however admirable and specialised our senses, our muscles, our joints, and means of expression, we should always respond in the same old ancestral way to any given circumstances, and should quickly come to disaster in the presence of any novel circumstances. We should not learn by experience, or, if we did, what would be the use, so far as behaviour is concerned? Whatever we came to know we should still have to behave in the same old way. There would not be a vestige of Will anywhere. But the meaning, above all, of the nervous system as we possess it is that it has the higher levels which make possible control, arrest, delay, modification of response; and somewhere within these processes what we call the Will must be found. Let us look at a simple but very familiar illustration, the facts of which are not in dispute.

If one leg be crossed over the other, and the crossed leg be tapped below the knee, it jerks, as we all know, this being called the "knee-jerk." Now, it is familiar to almost everybody that, in certain states of the nervous system, the knee-jerk shows peculiarities, for which the doctor looks when he examines it. For instance, in certain cases we find an exaggerated knee-jerk—the leg flies sharply forwards in response to the slightest tap. What does this well-known symptom of exaggerated knee-jerk mean?

We cannot understand it until we trace the details of the structure of the spinal cord. We then find that the cells concerned in the production of the knee-jerk are under the control of a long tract of nerve fibres which come down to the spinal cord from the brain. What these fibres convey is not a positive but a negative something. They control, inhibit, forbid. When they act weakly or not at all, the knee-jerk is consequently exaggerated, because there is lacking the customary control from above of the reflex arc, in the lowest nervous level, which is concerned.

A Study of Inhibition Through the Involuntary Knee-Jerk

Directly, therefore, an exaggerated knee-jerk is found we must look for the cause not in the machinery of the knee-jerk itself, not in the cells of the spinal cord (as a rule) or in the muscles or sensory nerves which convey the stimulus of our tap (as a rule), but in the path of inhibition which controls the reflex machinery from above.

Similarly, if a fracture, or some local inflammation, or a hæmorrhage, practically severs the inhibitory tract in the spinal cord already referred to, the knee-jerk becomes violent, and may even show a considerable series of spasms, instead of a single moderate response. Or, be it well observed, in a hysterical patient, whose characteristic mark is lack of self-control, the knee-jerk will be similarly exaggerated, just as the pulse may be unduly quick. She cannot help "letting herself go."

Now let us look at the recognised "paths of volition," which pass from the cortex cerebri to the spinal cord, and convey the orders which the motor-cells of the cord transmit, so to say, to the muscles. Suppose, for instance, that in walking or kicking

or swimming, a man wishes to extend the knee-joint, using the same muscles, and producing the same action as in the knee-jerk. Definite nervous tracts or tracks can be found, running from the motor centres for the legs, which are situated in the "psycho-motor area" of the cortex cerebri, down through the pons and bulb (most of them crossing over to the other side at this point), and then on through the spinal cord, in which they form what are called the crossed pyramidal tracts, and the direct pyramidal tracts (the latter composed of those fibres which do not cross). These are "the paths of volition," in so far as volition is concerned with the movements of the muscles of the limbs and trunk.

Man's Greatest Power—the Power of Saying No

Now, the remarkable fact, for which our special attention is demanded, is that these paths of volition are one and the same as the paths of inhibition which we discovered when we were studying the mechanism of the knee-jerk and its exaggeration. It is when, especially, the crossed pyramidal tract is *not* acting that the knee-jerk is increased, so that this path of volition is demonstrably a path of inhibition.

Only one department of medicine and of the medical sciences (if we may except the modern therapeutic practice of hypnotism) helps us as it should in our study of normal psychology, and that is the medical care of the insane. It is to be hoped that, in future editions of his "Social Psychology," Dr. McDougall will incorporate some more complete discussion of the real place of inhibition in volition, or self-control, as, perhaps, the most positive and personal and truly volitional of all a man's deeds.

In the case of the heart, if a man had volitional control of his vagi nerves, he could increase the rate of his pulse at will, and the act of doing so would be the arrest of the inhibition which, until that moment, the vagi were exercising.

The Will's Mode of Action—Letting or Not Letting Oneself Go

Similarly, in the case of the movements of the leg when a stimulus is applied, the way in which to get *more* response would be to lessen the controlling influence of the upper level of the nervous system. How much further cannot this be applied? If we conceive of the nervous system with its levels, must we not suppose that, the function of the higher levels being essentially that of control, the real acts of will are either those which exercise control, or those which relax control and "let us go"? In popular language, which so often expresses the psychological truth in forcible fashion, the real act of will is in not letting oneself go, or in letting oneself go. We find ourselves returning to the image of the horse and the rider.

The body in general, and the lower levels of the nervous system, are, so to say, the horse. Here are the motive machinery for action, the sensitive apparatus which receives stimuli, and the ancient, inherited mechanisms whereby those stimuli tend to arouse action. The powers available, at any rate for some time, are very great, as in the case of the normal heart, which could beat, for a time, twice as fast as it does, if it were allowed to. But the horse has a rider, who is its Will. Except in special cases, the rider uses neither whip nor spur, but his Will dominates none the less. Only he does so negatively, by inhibition. He merely holds the reins. If the horse is "high-spirited"—as our bodies are, in health—the problem is simply to control him, not to let him run away. At any given moment, for a sufficient reason, the rider makes the horse run twice as fast; but the making, the positive result, was in reality none other than a negative act, a diminution of the rider's inhibition.

Man a Machine, but with the Power of Self-Government

The difference is radical and all-important between the case of the horse whose speed doubles because spurs have been jabbed into its side, and the horse whose speed doubles because the pull upon its mouth has been a little relaxed. The suggestion made by those who have studied the importance of inhibition or control in the behaviour of the nervous system, and of the mind, is that, in the case of the *Ego*, the very Self, and all beneath it, we have the living image, within a single being, of the horse and its rider. And the Will is, above all, the power to say "No," the Will which *will not;* which says you may not, or, at times, you may.

In some respects the analogy of a motor-car and its driver is no less instructive. The driver puts no power into the car. It gets its power from the chemical energy of petrol, and it rigorously obeys and illustrates all the laws of physics and chemistry, the law of inertia, the law of gaseous expansion, and so forth. When the car is running, its structure is such that it supplies itself, automatically, with the fuel it needs to burn and the air it needs to breathe, just as the

body does. The supply of fuel it carries would suffice for very extensive occurrences if it were used with sufficient speed, and the apparatus is provided whereby the supply of fuel to the engine can be made very considerable. The art of driving the car largely consists NOT in pushing or urging it in any way, but in controlling the degree of activity to which its structure and supply of power make it prone. The car that had a Will of its own would similarly have to use that Will, not to order, but *to order not*. Such a machine, with a Will to govern it, is man.

But controlling the power of a motor-car is not the whole of driving it. We have to steer. We do not make the power in the car, nor affect the "laws of physics and chemistry" as they display themselves in it, but we guide the issue of their action. The car goes uphill when gravitation tends to pull it down, because we so *direct* the forces which are being evolved in it, and so increase their quantity, when required, that the car has no choice. But we have.

Or think we have. For there are many great thinkers and many formidable arguments to suggest that our choice is an illusion, and that, in fact, we have no choice at all. So far as self-control or inhibition is concerned, there is no dispute.

Does Will Direct Our Actions or Only Control Their Intensity?

The physiology and anatomy and pathology of the facts have been worked out. Through certain parts of the nervous system there is a control exercised over the other parts, and through them over the body in general. But the control we have discussed hitherto is only a matter of mechanical degree, like the control of a motor-car whose steering-wheels are locked. We may affect its speed, or even stop it altogether, but we cannot direct it. Does the Will *direct* the Actions of a man, as well as control their mere quantitative intensity?

The obvious reply is Yes. We are aware of choice within ourselves; we feel ourselves free to take the turning to the right or the turning to the left, and we take which we please. But, whether we are actually driving a motor-car, or merely driving Shanks's mare, it can be argued that our choice at the fork in the road is *not* free, though we think it is; and, further, that in all our acts whatever the feeling of freedom is an illusion, our choice is unreal, the course we shall choose is forced upon us; the Will is not free but bound; we are not self-determined, but the rest of things determines the self.

Here, of course, is the ancient controversy still unfinished, between those who hold the doctrine of the freedom of the Will, called "libertarianism" or indeterminism, and those who hold the opposite doctrine of "determinism." This controversy has always been, in large degree, a war of words, the disputants meaning different things by the same terms, and the same thing by different terms. Many of those who have devoted themselves to it have come to the conclusion that it is less important and real a dilemma than they used to think. Some of us have "circumnavigated the metaphysics," as Robert Louis Stevenson said, in our youth, and have come to the conclusion that we are where we were before our voyage began.

Do We Choose, or Does Our Environment Choose for us?

The study of behaviour, the problems of conduct, are not affected by this controversy as we used to think. Let us try to show how this is so, contrary to popular and especially to theological opinion, and the rest of the discussion may be left to some other than the purely scientific arena.

The teaching of science, according to the best evidence and logic we can avail ourselves of, is that the Will is determined by "heredity and environment," or "nature and nurture." These have made, are making, will make us, what we have been, are, and will be. According to what we are at any time, so we act; and since the action flows naturally from what we then are, we feel it to be the free choice of ourselves. But, in fact, we are simply doing what we are so constituted as to do, we being what we are, and the circumstances being what they are. Perhaps we seem to be clearly and freely choosing between two courses, but, in fact, there is only going on a trial of strength between various instincts, impulses, tendencies, some inherited, some due to habit or education, which are within us, and the strongest will win and make the choice for us.

If Our Lot is Determined for us, Where is Our Moral Responsibility?

When this is asserted, certain classes of mankind rise up at once in alarm and indignation, declaring that this theory of the Will abolishes moral responsibility, undermines morality, strikes at the very root of punishment and reward, here or hereafter, of blame and praise, of all ideas of relative merit or discredit in the actions of ourselves and our fellows. No wonder that, in such a belief, men have indignantly repudiated the doctrine of determinism.

But we have only to think fairly in order to see that two different things have here been confounded. If we punish people for revenge, then indeed the determinist theory —which points out that, for example, the poor fellow's father had an ungovernable temper, too—exposes our brutality and injustice. But if we punish them—or reward them—on the determinist theory, which admits the causation of the Will, we are justified, for our punishment is a new factor in causation, which may cause the Will to take another course in future; or our reward is a new factor which prompts the Will of the person rewarded, and of others, to do the acts which we consider worthy of reward.

The Part Played by Rewards and Punishments in Forming the Will

In fact, every useful and humane and rational theory of moral responsibility, of rewards and punishments, praise and blame, involves the determinist view that the Will is determined, and seeks to determine it accordingly. This is the only ground on which the showing of moral approval or disapproval can be defended, because of the effect produced upon the determinable will of others. On the contrary, when we do not hold this theory of the will, but regard it as having no causation (which is, when frankly stated, incredible to all of us), our only excuse for punishment must be in order to satisfy our own desire for vengeance. From this desire alone proceeded the forms of punishment which the advancing humanity of man now discards.

The scientific idea, on the other hand, is identical with the humane and useful one of, say, any good parent. He sees and knows that the Will of his child is determined, as by his own smiles or frowns—even though he may be a believer in the "freedom of the Will," in some meaningless sense, he knows that his actions influence his child's actions. And so he acts accordingly, with rewards and punishments from smile and frown, down to the crudest methods of sweets and slaps.

The Modern Theory of Punishment in Relation to Criminality

The parent will not be so foolish as to blame the child, or praise it, as if the child had freely chosen to create itself as it is; but he blames and praises because these are influences which determine the child's determinable Will. And what the modern psychologist and educationist and criminologist demand of the State is not that, in its dealings, for instance, with criminals, it shall cease to deal out punishments—on the ground that, the Will not being "free," the criminal is not "responsible" and must not be punished—but that it shall deal out punishment or treatment which affects the Will of the criminal in the right direction. In a word, we want the penological theory to be reformative instead of merely vengeful. We say to the State the Will *is* determined, and your duty is to determine it aright. This, indeed, is the very meaning and idea of, say, the Borstal system and of all moral education the whole existence of which would be an absurdity if the Will were not determined but "free."

The reader is asked to observe that we do not here profess to have dealt with a subject which is perhaps outside the scope of science in the ordinary sense; we have only sought to show that the doctrine which recognises the determination of the Will is the very doctrine which, in fact, we assume when we call people responsible for their acts, and treat them accordingly. It is only the lunatic whom we must not regard as responsible, and whom, therefore, we must not punish, and that is because, in the disordered state of his mind, the normal manner in which our Wills are determined is in abeyance, his Will is indeed "free," because it is in a chaos, because it cannot be determined in the normal way, and therefore he cannot be held responsible for it.

The Theory that the Will is Not Psychical, but a Muscular Operation

We pass now to another question which is fundamental to all progress in the study of the Will. The psychological school of the nineteenth century laid down the doctrine that, even though the Will be something real, more than merely a complicated form of reflex action, yet it can only issue as reflex actions issue—in movements. In other words, we can only will the contractions of muscles. Professor Bain, the great psychologist of Aberdeen, maintained this view, and it has representatives today. It is so nearly true that we think it must be wholly true. If it be wholly true, the mechanical aspect of the Will seems to triumph, and what we call the Will becomes no more than a kind of complication in the passage of a stimulus from without, and the corresponding movement of muscles from within. The Will as a psychical fact seems almost to disappear.

But we have only to examine ourselves in order to discover that we can will other

things than movements. We can will the retention of an idea, a phrase of poetry or music, in our consciousness, when other things are tending to replace it. We can will the direction of our thoughts. Lying in bed, in the dark, merely allowing our thoughts to wander on, we can deliberately turn away from one subject or fix the mind on another, simply because we choose to. Not only are such acts as these acts of Will, but they are the purest and most indisputable expression of the Will.

Some writers have said that, when we will to attend, the act is in fact an act of muscular contraction, for we are fixing the eyes, or straining the internal muscles of the ear, or holding the breath, in order to attend. Of course, that is true of the act of attention, say, when we resolve that we *will* listen to the dull lecture or sermon or symphony, though our attention is wandering. We squarely plant ourselves opposite the sound, and place the body and the sense organs in the best position for hearing.

But no such explanation avails for many other cases, such as that we have cited, where no muscular act of attention is or can be involved, and where we internally choose to arrest the current of thought that was tending to set in one direction, and to set it in another.

The Control of Thought—Something which Cannot be Explained in Mechanical Terms

This is a purely psychical act, issuing in no contractions of any muscles; and it was a pity that certain writers, in their desire to refute those who believe in the *psyche*, should have laid down the doctrine that we can only will movements, when part of religious and moral training is, and always has been, the right use of the Will in directing the course of our thoughts. The very party against whom the materialists were fighting was the best equipped with first-hand knowledge of the power of the Will to effect consequences which cannot be stated in terms of mechanics, but only in terms of thought.

Here, as we all realise at once, we are in the presence of the central mystery of "mind and body." Here something happens which is in no sense a mechanical process. No mechanical terms or ideas avail to express it at all. No physicist can measure it in terms of transformation of energy, or the movement of so much matter through so much space. The recognised physical ideas of "energy," "force," "work," are inapplicable. This is a piece of psychical work of another order than that upon which the doctrine of the "conservation of energy" has any bearing. The act of Will may result, immediately or at any time, in various movements, and in all those movements the law of "conservation of energy" will be observed. There is here no infraction of physical laws. The physical energy is not made by the Will, nor destroyed by it. Only here is a psychical act which cannot be expressed in any physical terms.

It is an act, above all, of *attention*. We choose that we shall attend to what we choose. Further, even when the act of will is an ordinary voluntary movement, psychologists have shown, from Herbert Spencer to William James, that what really happens follows from the intense attention paid to the idea of the movement. When the idea of the movement is strongly enough presented to the mind, and attention to it becomes intense enough, we perform the movement.

The Part Played by Attention in the Phenomenon of Will

Everyone who has taught anyone else to bat or to swim or to skate or to sing knows that this is the way of success. You do not say to your pupil, "Now innervate the biceps flexor cruris, the latissimus dorsi and the psoas muscles," because no anatomist even can do these things. We cannot will the contraction of muscles, but we can will movements, if we have the idea of them. Therefore the teacher makes the stroke, attacks the high note, cuts the figure, and then tells the pupil how he feels while making the movement—what kind of idea of the movement he has. Then the pupil, firmly keeping this idea of the movement in the full blaze of his attention, succeeds in making it for himself.

Hence the conclusion reached by Professor James, that "the essential achievement of the Will is to attend to a different object and hold it fast before the mind," and that "effort of attention is thus the essential phenomenon of Will." And why do we attend to one thing and not to another?

Hypnotism Only Possible with the Assent of the Will

If the Will is not "free," but caused, what causes it? The answer is that the very Ego, or Self, of each of us, the idea that each of us has of himself or herself, is the determining factor of the Will. "I am going to do this," we say, and what "this" is will depend upon what we are, and especially upon what idea we have of ourselves.

For instance, Dr. Milne Bramwell, the well-known authority on hypnotism, has

pointed out the error of the popular view that the hypnotist can suggest a wicked act, such as murder, to the hypnotic subject, who will thereafter go and commit the act. Experience shows that hypnotised people will not accept suggestions which are contrary to their moral character and their idea of themselves. If the suggestions are opposed to the character of the individual, the will resists them, and they will not issue in action. The apparent exceptions to this rule are probably not exceptions—the wrong act was *not* opposed to the character of the individual, and the will, therefore, could accept the suggestion to perform it. But a vast amount of nonsense that has been written about hypnotism, and especially against it, is disposed of by the experience of hypnotists in this respect, and our view of the nature of the Will helps us to understand the facts. Above all, the Will issues from the very self of the self, the very essence or nucleus of one's character.

Of course, if a man has no formed idea of himself, no sentiment or self-regard (not conceit or vanity), which says, " No, *I* do not lie, or steal, or break promises," or which says, " I have made up my mind to achieve such and such a purpose, and my Self is for that at all times "—then he has no real Will at all. He will be vacillating, infirm of purpose, and of him it may be said " Unstable as water, thou shalt not excel."

The Importance in Education of Forming Right Ideals in Willing

Part of moral education, therefore, consists in developing the idea of oneself as a being who does not do certain things, and does do other things. This idea of oneself will then determine the Will. If we always scold a child, say that it is naughty, expect it to lie and be dirty, and give it that idea of itself, it will behave accordingly ; and so will a young convict or " juvenile delinquent." If we try to develop other ideas of self-regard in the high sense—as when we say, " but a little lady could never do that, and you're a little lady, aren't you ? " or when we remind a youth of high rank that " noblesse oblige," that just because he is what he is he must be courteous to the poor and the old, must be chivalrous and honourable—we are then deliberately fostering an idea of self which becomes part of the character, part of the essential man or woman, by whom the Will is determined.

Now let us go back to our view, derived from physiological considerations, that a very large factor or constituent of Will is inhibition or self-control. We shall see that this theory entirely consorts with what we have been saying. Though Dr. McDougall seems to do much less than justice to the place of inhibition in ordinary acts of Will, he certainly recognises the principle at the end of his discussion on the subject, where he refers to the " sentiment of self-control," and says " Of all the abstract moral sentiments, this is the master-sentiment for volition, and especially for resolution. It is a special development of the self-regarding sentiment. For the man in whom this sentiment has been strong, the desire of realising his idea of self-control is a master-motive that enables him to apply his adopted principles of action, the result of his deliberate decisions, in spite of the opposition of all other motives.

The Power of Self-Respect in Shaping Behaviour

" The operation of this sentiment, more than anything else, gives a man the appearance of independence of the appeal of the voice of society, and of all other persons, to his self-regarding sentiment. It enables him to substitute himself, as it were, for his social environment."

Every first-hand student of mankind knows what self-respect means for a man's behaviour, and how, when once we find ourselves capable of some unworthy act, we think lightly of committing it again—a fact which applies everywhere, but above all in the sphere of sex ; and how, on the other hand, our worthy achievements raise our self-respect, and make their repetition easier thereafter. If, then, we develop in children and in ourselves those ideas of human rank and power and destiny, and of our own natural capacity, or capacity through the help of home or religion, to act as men act who are worthy of the name, we shall find the Will, with this idea of the Self behind it, issuing in fine behaviour.

Man's Belief in Himself the Secret of His Rise

From this point of view every cynic, everyone who teaches that men are only animals, everyone who tries to haul down the flag of humanity, is a traitor in the crew. And the best friends of mankind are those who teach that it is in man to be great, to show something of the Divine, to die for his mate or for an idea, to reach, however slowly, towards the stars. This is the secret of the great religions, great reformers, great teachers. They believe in mankind, they make men and women, boys and girls, believe in themselves, and the rest follows.

"UNTWISTING ALL THE CHAINS THAT TIE THE HIDDEN SOUL OF HARMONY"

AN ARTIST'S CONCEPTION OF THE POWER—"MOST MUSICAL, MOST MELANCHOLY"—OF THE POETRY OF SOUND. "BEETHOVEN." BY L. BALESTRIERI

THE CARE OF THE SENSES

Practical Hints on the Preservation of Comfortable Sight and Unimpeded Hearing

THE CHEAPNESS OF SOUND TREATMENT

BEFORE we pass on to the health and happiness of the mind, there is one part of the bodily structure, and that the nearest to the mind, which we must specially consider—namely, the organs of sense and their working. We talk much of "exercise," but by that we never mean anything other than the exercise of the muscles. Yet the senses are infinitely more characteristic of man than are his muscles, and far more important for his happiness and efficiency, and they, too, may need exercise, and certainly need care.

This is, in large measure, a question of those concerned with the education of the young. The adult is, in this respect, fairly well "done for"—at least, as far as actual development of the senses is concerned, though it is still his duty to take care of what he has. But childhood and youth offer opportunities for the educative exercise of the senses such as were totally neglected in the systems of the past, and are only now beginning to be recognised as clearly in our own day as they were by the ancient Greeks.

The increased interest in music of sensible type, such as folk-songs, the revival of morris dancing, and other natural and healthy forms of dance, the use of Nature lessons, of open-air excursions for botanical or geological or definitely artistic purposes—these are examples of a new interest in the education of the senses, such as certainly will make their use more enjoyable in after years, and most probably also make their future health more stable. While care of the adult's own senses is mostly a matter of "medical" precautions, the care of the senses in childhood must not be merely medical and surgical, merely negative and protective, but must also be positive, constructive, and educative.

For practical purposes the care of the eyes comes first in importance, and it is exceedingly well worth while. If ever a stitch in time saves nine, it is here. The importance of the teeth in relation to the general health has been vastly underrated. So with the eyes. In each case a special department of the body, which is a whole, has been given over to a group of specialists, and the relation of their work to that of the general physician and hygienist has been largely missed. We are now getting truer ideas of the facts. Especially are we indebted to the clever and original, though doubtless exaggerated, studies made by Dr. George Gould, an American surgeon, of what he calls "eye-strain." He regards strain originating in the eye as the source of most of the minor ills of civilised life. In his "Biographic Clinics" he has studied the lives of many distinguished men, such as Darwin, Spencer, and Huxley, all of whom suffered from chronic dyspepsia, and has argued that, without knowing it, they were really the victims of eye-strain, which the attention of a skilled oculist and the provision of a suitable pair of lenses would have cured.

No doubt Dr. Gould "protests too much." Thus the statement in Herbert Spencer's Autobiography is that the characteristic symptoms of so-called "eye-strain" were produced in that case whether the patient read or was read to. But when a liberal allowance is made for enthusiasm and the intoxicating influence of a good theory, we may be sure that Dr. Gould's main contention is largely right. The reader who suffers from vague, shifting symptoms of headache and dyspepsia and malaise, whose internal machinery is properly active, and in whom no obvious cause of the symptoms can be found, would do well to consult an oculist. But it is only fair in this connection to add that

very expert diagnosis and prescription are required. Many young people, with long sight and bad headaches, are promptly cured by a suitable pair of glasses, which any reasonably competent optician can prescribe. But many more, and especially older people, who are not necessarily long-sighted, go to the optician or to the general practitioner for relief, are prescribed glasses, and wear them, without anything but, perhaps, increased discomfort.

The Importance of Seeking Special Advice in All Cases of Eye-Strain

Really delicate "refraction work," as it is called, needs very special training, and even very special apparatus. No one has these at his command who does not devote himself to the study of the eye. Part of the modern theory of "eye-strain" depends upon the fact that, in many people, what is called the "muscle-balance" of the eye is not perfect. In such persons each eye may be carefully and separately examined as regards its refractive power, and lenses prescribed accordingly, without any relief resulting. The fact is that, though the patient has not an actual squint, the two eyes are not just so perfectly balanced that the image of any object falls *exactly* on the corresponding parts of the two retinæ. In order to see properly, therefore, and to the full advantage of "binocular vision," the patient is all the time straining a little, so as to correct this faulty balance. He requires a special kind of lens, neither spherical nor cylindrical, but prismatic, in order to compensate for the error, and then he will be happy. But only the expert oculist can detect and remedy this condition. Many such oculists, in the past, have rather despised "refraction work" as mechanical, and have been content to leave it to be done, more or less well, by opticians and general practitioners, but now they are coming to see that this is a kind of work which is worth doing just as well as possible, and the amount of gratitude they often receive and have fully earned is surprising.

The Eye Originally Designed for Effortless Vision at a Distance

Our first advice to the reader, therefore, is that, when symptoms exist and do not yield to ordinary treatment, a single consultation with an oculist of standing may involve the best investment the patient ever made.

So much for this vague, dubious, but certainly important subject of eye-strain—the influence of faultily working eyes upon the behaviour and comfort of the rest of the body. Now we may proceed to consider the health and durability of the eyes themselves—which in "eye-strain," so-called, need not suffer at all, though they cause so much discomfort and disordered function elsewhere. It is not necessary here to do more than remind ourselves of the elementary fact that the normal eye is made for effortless vision at a distance, with an apparatus for occasional use whereby it can be focussed upon near objects. The eye was made for him who hitches his waggon to a star, whose eyes are almost ever focussed upon infinity. But civilisation, as it proceeds, involves a steady abbreviation of the range of vision. The use of the eye for reading and writing has become dominant, and while this involves continuous effort for even the normal eye, it involves still more for the long-sighted eye.

There is no doubt about "eye-strain" in such cases, at any rate; and it is, of course, a refinement of cruelty, to say nothing of useless incompetence, to spend money and skill and time upon the "education" of a long-sighted child without somehow or other providing it with suitable glasses.

What is the Significance of the Prevalence of Short Sight?

If the State cannot afford to provide the glasses, it certainly cannot afford to provide the "education"; and if the father cannot, then assuredly he should not be allowed to afford the price of his pipe and his beer. At any rate, the child's health and education ought not to be sacrificed to the Moloch of competing political theories.

Short-sightedness, or myopia, however, is much commoner than long-sightedness, or hypermetropia, and is certainly becoming more so. The use of the eye at short distances alters the shape of the eyeball, so that it becomes more suitable for near vision. Thus we adaptively make ourselves short-sighted. So much was noted in the discussion of the physiology of vision in Part 20 of POPULAR SCIENCE, and here it is our business to consider the implication of these physiological faults, for the hygiene of the eyes in childhood and adult life. In the first place, if it be true that the short-sighted eye is the best for use at short distances, we must reconsider what may be called the purely medical estimates of the degree of ocular defect in the community.

Thus, we are told that in one school in Philadelphia two-thirds of the children had defective vision, and that of the three-quarters of a million or so of school-children

n London "ten per cent. have less than one-third of normal vision." What exactly do these alarming statements mean? They are largely quoted by a class of Eugenists, by sensational writers, advocates of political panaceas and so forth, in favour of the view that "we are going to the dogs as fast as we can." But if the eyes of the short-sighted man do not tire, if he never has a headache, if he can read or write for hours on end, daily, without any injury or strain, what exactly is the significance for him of the fact that perhaps he has "less than one-third of normal vision"?

The Advantage Under Modern Conditions of [illegible] Strong Sight

That staten[illegible]t he does not focus ve[illegible] certain distance. T[illegible]m from recognising [illegible] across the street, or fr[illegible]l by-play at a theatr[illegible] a pair of lenses will co[illegible]oses to use them. Wh[illegible] Germany Cohn finds [illegible] cent. of the lower class[illegible] or myopic, while fift[illegible] the upper classes ar[illegible] we have to ask whe[illegible]ther welcome [illegible] do his appointed wo[illegible]fort, while his neighb[illegible] his "strong eyes," cannot rea[illegible] h[illegible] without the beginnings of a headache. Such terms as "good eyes," "strong eyes," "bad sight," and so forth may be only too full of meaning, but they are commonly employed about nothing more vital than the mere shape of the eyes in question.

Hence there arise several questions which we may reasonably begin to think about, as, for instance, what shape of eyeball is best fitted for civilised life? How is that shape of eyeball to be best attained—*e.g.*, by what kind of discipline or employment during school life? What shape or shapes of eyeball can legitimately be called normal?

The Absurdity [illegible] Assuming National Degeneracy Because of Short Sight

Is the vision defective, or an "affliction," which can be used at a few inches for hours on end, but is uncertain about the identity of people across the street? Or is that defective which requires no glasses at the theatre or in the tennis court, but brings on a headache with half an hour's reading? The upshot of these inquiries is that the natural state of the eyes of our school-children is not nearly so bad as the alarmists make out, and they only spoil the excellent case for attention to real disabilities by talking of "national degeneracy," because there are many children in the schools with eyeballs rather too long or too short from back to front. Doubtless there always have been such children.

Of course, it is impossible to prescribe suitable glasses for any pair of eyes until they have been individually examined, but certain general observations about glasses may be usefully made here. Short-sighted people, without special cause, do not require to wear glasses. Their health, and that of the eyes, does not suffer if they use no glasses—it being assumed for the moment that the two eyes are similar, and the muscle-balance perfect. But while the person who has no refractive error but symmetrical short-sightedness need wear glasses only for the sake of clearer vision at a distance, the long-sighted person must wear glasses for near work if he is to be comfortable. The disfigurement produced by the glasses may be heartily objected to, but it cannot be helped. So much for the simple cases of both short and long sight.

A Usual Reason Why People with Short Sight Should Wear Glasses

But directly the case is complicated, as it very often is, even the short-sighted person should use glasses. Thus, in many people the [illegible] eyes are not exactly of the same shape. If they are to be [illegible] perfectly together, without strain, unequal [illegible] correct the disproportion. If t[illegible] great, one eye [illegible] keep up with its advantage[illegible] will no longer be moved together with it, [illegible] good is to be done, so it is not worth the trouble. The "fixing" eye proceeds to "fix" the object looked at, but the other remains unmoved, and the result is a squint. A most cogent reason for supplying glasses even to very young children is thus furnished, in order to give the less fortunately shaped (commonly and wrongly called the "weaker") eye such an advantage as to place it on terms of equality with its fellow. Parents do not like putting ugly goggles on a little girl's face because she is, perhaps, only occasionally observed to squint, but this will be the truest kindness in the long run, even or especially from the very point of view of looks.

The lenses must be properly made, with just the right width between them, so that the centre of each lens comes just in front of the centre of the corresponding eye. The optician must therefore measure the exact distance between the two eyes, and supply a

frame accordingly. The eyeglasses without rims to the lenses are nowadays quite satisfactory, and if the frame is the proper size there is no objection to them. Eyeglasses should not be persistently worn too tight, as serious ulceration of the skin may sometimes be thereby started.

When studying the hygiene of light in the ninth chapter of this section, we confined ourselves to the praise of sunlight and its adaptations. But special questions, not yet dealt with, arise when we consider the care of the eyes. Often we have to use them by artificial substitutes for daylight, and these substitutes vary widely in colour, intensity, steadiness, heat, and other characteristics. The safe rule to follow is that substitutes for daylight should reproduce its conditions as closely as possible, for there is every reason to expect, on evolutionary principles, that the kind of light which will suit the eyes best is that to which they have been adapted for ages past. Some day, or night, we shall be able to produce artificial light the constitution of which is practically identical with that of sunlight. Several physicists and chemists are working at this problem now, introducing various metals and salts into the composition which is made luminous, whether by gas or electricity, so that the rays emitted shall be as if from a tiny replica of the sun.

Dangers to the Eyes Concealed in Artificial Light

The forms of artificial light in present use may and do often contain ingredients unsuited to the eyes, and these need not necessarily be visible, but may lie above or below the visible spectrum, and be potent nevertheless. Here is a very real source of possible injury to the eye, and it is one which no arrangement of lenses can do anything for. We must have an artificial light which contains abundance of the rays which most stimulate vision, and, for the rest, a fair amount of bluish rays, but a minimum of hot red rays. A conspicuous example of the kind of light by which we should *not* read is firelight, which has another serious objection besides its hotness. On the other hand, the light of the mercury-vapour lamp is much praised for using the eyes by.

Two great characteristics of the daylight which is best for vision are, first, that it is diffused, and, second, that it is steady. The steadiness is most valuable, and in this respect electric light is as great an advance upon the gas-jet as that was upon candles. Observe that we have referred not to sunlight, so splendid for many purposes, but to daylight, as the best for using the eyes by. Daylight differs from sunlight in that it is reflected from cloud and sky and so forth, thus coming from a diffused surface. The source of artificial light should similarly be diffuse, so that we cannot tell where the light actually comes from, as is usually the case in our use of daylight. When we speak of a "soft light" we mean one which does not hurt or fatigue the eyes, and the typical "soft light" is diffused daylight.

The Strain on the Eyes Caused by the Use of the Arc Lamp

A famous student of this subject, Lord Rayleigh, concludes that the "softness" of a light is proportional to the surface whence it comes—that is, other things being equal. The light of sodium vapour, mercury vapour, and an arc lamp cannot be usefully compared in this respect, but light of a given kind is softest when it reaches the eye from a large surface. In many modern halls the lights are concealed, and the hall is lit by reflection from a surface which they illuminate.

Recent French observations have shown that light of a given intensity has a very various action upon the pupil of the eye according to its quality. A naked arc lamp causes such contraction of the pupil that we only employ a small fraction of the light offered. The waste, in terms of money and health, is obvious. Light of a similar intensity, due to an incandescent lamp, is utilised to double the extent, for the pupil contracts so much less. Thus the use of arc lamps in restaurants and other places, as one may occasionally see abroad and even in this country, is to be condemned as both wasteful and injurious to the eyes.

The Modern Need for Toned Light Rather than for Brightness

Nothing fatigues the eyes so much as the arc lamp, as has been proved by noting the duration of "after images" produced by various kinds of light of equal intensity. In a certain huge room outside York, where six hundred girls daily pack chocolates, arc lamps are employed, but they are shaded, and the light is thrown down to the floor by reflection from the ceiling. This is an example of the way in which to light a large enclosed area, and Messrs. Rowntree now have many imitators.

We see, then, that light should not be too bright, and it should also not be too faint. Children's eyes, no doubt, are often

injured by defective lighting of schoolrooms. But the tendency nowadays, when electric incandescent lamps are so cheap and powerful, is rather towards the use of too much light than too little.

The walls of our rooms should be simply covered, for choice without patterns. The green of Nature is restful and beautiful, and we can safely reproduce it nowadays in our rooms without fear of arsenical poisoning. Dead white we shall use with care; all that glitters is not good for the eye.

Practical Hints for the Use of the Eyes when Reading or Writing

When we sit down to read or write we shall habitually observe certain simple precautions. We shall not sit facing the light, but with the light coming over either shoulder if we are reading, and over the left shoulder if we are writing. The light, of course, will be "soft," strong enough, but not too strong, diffused, steady, and as nearly the colour of daylight as may be. Neither in reading nor writing should the head be too dependent. This error is difficult to avoid, but it must be avoided by those whose eyes give them any trouble, whose eyelids tend to become heavy, and in whom the conjunctiva, or lining of the lids, tends to itch or smart. Most of these troubles of the eye depend essentially upon congestion of the conjunctiva with blood; and just as we raise a limb in which the veins are varicose, so we should not drop the head, thereby calling in all the power of gravitation to prevent the proper return of the venous blood from the delicate capillaries of the conjunctiva.

Those who use their eyes very hard at short range do well to give them intervals of rest occasionally, thereby giving the ciliary muscle, so continually employed in the act of accommodation, what we may call a "breather."

The Advisability of Giving the Eyes Rest by Change

The eyes may be shut, or we may look out of the window at the landscape (which involves relaxing the accommodation), or we may even look at landscape paintings in a room, an act which has the same effect. But, as regards the infant and the child, such warnings and advice are out of place, for the simple reason that there should be no such continuous use at short range to be relaxed. The eye of the infant and of the child is normally long-sighted. The proper work of a young child is its play—the right kind of play, involving the use of the eye at the range for which it is suited. The time will come soon enough when the eye has to be used at shorter range, and the length of its axis will be adaptively modified.

There is much to be said and done about the details of reading. Strong arguments exist in favour of the use of black paper for books, with white ink, thus affording the eye rest everywhere, except where there is something it wishes to see. At present, of course, the eye is stimulated and worked by everything but the letters. Type should be large, solid, "honest." All sorts of elegant and archaic type may be commended on artistic grounds, but they have no claim to utility. Letters should be as unlike one another as possible, and their form should be clear-cut and without superfluities. The preposterous form of the German letters is regarded by many German authorities as largely responsible for the extreme and increasing short-sightedness of those who are compelled to read them.

Let the eye be attended to in time. Danger is so easily averted, and damage is so difficult to repair. If a really skilful dentist is worth far more than his fees, so is a really skilful oculist.

The Dangers of Inexpert Treatment of the Eye

Confident ignorance and half-knowledge do terrible harm here, and glass eyes are not nearly so useful as false teeth. The optician or the general practitioner may be right nine times out of ten in his prescription of lenses, but the tenth time he may be wrong. He may drop atropine into an eye which he wishes to examine further, and in the hope of doing good, with the result of precipitating an attack of glaucoma, which will ruin the eye for ever. When it comes to dropping atropine into eyes, the expert is the man to consult. Many a blind man, blinded irremediably by glaucoma, would be seeing today if neglect to consult an expert in time had not ruined his eyes, or if the pressure within them, already too high, had not once been fatally raised by drops of atropine, which dilate the pupil, bunch the iris together in a mass which prevents the fluids of the eye from circulating properly, and so raise the pressure to a point at which the retina lays down its task, without repair. On the other hand, if cases of incipient glaucoma are seen in time, a delicate and simple operation will relieve the pressure, at the cost of a snippet of the iris, and will save the sight.

By far the commonest of all causes of blindness is, however, of a different order. It is due to infection by a minute microbe known as the *gonococcus*. Practically never does this microbe attack the eye except in one instance, which is at birth. As many a baby opens its eyes to the light for the first time, it receives the infection which will shortly blind them for ever. This unspeakable abomination occurs every day in every civilised country, and it is entirely preventable.

No doubt the infection should not be present. But even if it is, the eyes can still be protected; and though the *gonococcus* be absent, other microbes may very likely attack the delicate eyes of a baby.

The Terrible Results of Inattention to the Eyes at Birth

The rule is therefore absolute, admitting of no exception, in the palace of a king or an archbishop, or in any slum, that the eyes of the new-born child, within a minute or two of birth, and as the most essential part of the business of washing the child, shall be separately, slowly, repeatedly swabbed out with a liberal supply of a mild but active antiseptic. Weak solutions of the salts of silver are often used for the purpose, about as good as any to which a precious metal may be put. Regulations in this respect are enforced under the Midwives Act, and any midwife who neglects this duty should be thenceforward deprived of any opportunity of discharging it.

The general estimate is that not less than one-third of the blind inhabitants of any civilised country owe their misfortune to neglect within the first few minutes after birth. They are usually described as having been " born blind," but that is a lie. They were born seeing, with normal, perfectly formed eyes, and they were then blinded. The intense inflammation produced by the *gonococcus* leads to destruction and ulceration of part of the cornea. In due course this heals, but the scar is opaque.

The Curse of Noise and the Soothing Power of Music

Lately a surgeon has succeeded in grafting a piece of transparent cornea, from an eye removed from another patient for disease of another kind, so as to replace part of such an opaque scar, and thus a little window has been let into a blind eye. One such achievement is worth noting.

The only other sense which requires our consideration here is the hearing. As we have already observed, modern urban civilisation imposes specially severe burdens upon this sense, with penalties which show themselves partly in disturbed and dreamful sleep, and partly in the consequences of imperfect ventilation, for we are constrained to shut out air in order to shut out sound. Citizens of the next generation will be much more careful to keep their cities quiet. At the other extreme from noise, with its harmful influence, is music, the hygienic and therapeutic value of which has been believed in for many ages, and about which much might be written. Music of the right kinds, rightly employed, has a healing and soothing power, as well as possibilities of exhilaration not lightly to be discounted. Music is pre-eminently the social art, as has often been observed, and as the history of its evolution proves. Hence we may well expect some help from it in the care and treatment of the insane, who are typically a-social—not necessarily anti-social, but simply not social. And that is what we find. Only the very worst cases in any ordinary lunatic asylum fail to respond to, and even be partly made social again by, the bond of sympathy and of common interest which music affords. In all modern asylums music is freely provided, as a really therapeutic measure. It has the " healing power " which Matthew Arnold discerned in Wordsworth's poetry.

The Insufficient Investigation of the Ameliorative Influence of Music

Experiments in the therapeutic use of music were made in general hospitals some years ago, without notable results. Such experiments, repeated with more wisdom and in direct relation to nervous and mental cases, would repay any investigator today, when so much more is being learnt about the psychical side of disease. Nearly all of us have felt at times like Saul in Browning's great poem, though perhaps not on so gigantic a scale, and many of us have been helped by music, as he was by young David's harp. Of course, there are morbid and healthy kinds of music, as of all forms of artistic product. One does not necessarily mean that the ill or weary or depressed are only to hear jolly, happy music. There is a noble sorrow—the sorrow of noble men for noble objects; and such sorrow, as expressed in the music of Bach or Beethoven, may be much healthier in its influence than the inebriated joy of some other composers.

The structure of the aural apparatus demands due care, no less than that of the eye. No one allows a quack to operate upon or manipulate the structure of the

eye, because everyone knows how delicate and complex an organ that is. Unfortunately, the aural apparatus is invisible, except for that degenerate sound-catcher which, in rather long-eared fashion, we call the ear. But when one has seen the middle and internal ear, one is as likely to tolerate the ear quack as the eye quack.

Of course, the layman is not in a position to judge of the real skill of those whom he consults, though clearly a surgeon who works at an ear hospital is likely to be properly qualified. But at least the layman can have the elementary sense to go further, rather than be content with the man who treats the ear without examining it by means of a good light reflected from a mirror into the external canal, so that the drum of the ear can be seen.

The Crime of Failing to Prevent After-Effects of Childish Ailments

Just similarly the layman will be wise to mistrust anyone who professes to deal with his eyes without using the ophthalmoscope, or to prescribe for chronic hoarseness without using the laryngoscope.

"Artificial drums" for the ear have been repeatedly tried in vain, though mere simple pellets, such as aural surgeons use, may do something. The best course is *not to let the drums be pierced by disease*. Practically never need this happen. If cases of scarlet fever were properly looked after, if adenoids were dealt with, if the pernicious delusion that measles is "only measles" were dispersed, then infection would not reach the middle ear from the throat at all, and there would be no pierced drums to deal with. That is not our method in this country, where we have had the girls in the schools for forty years and more, and have never yet told them that measles and whooping-cough *kill* tens of thousands of children annually, and that to expose a child to measles, or to neglect it when it has measles, is a crime against the child and against the State, and should be punished by the law.

The Secret of Having a Pleasant Voice that Lasts

Though the larynx is not a sense-organ it is closely related to sensation, and the throat is common both to the ears and to the larynx. A few words may therefore be said here as to the hygiene of the voice. In the presence of adenoids or of enlarged tonsils, or a polypi in the nose, or a deflected nasal partition (between the two nostrils), the larynx is always liable to give trouble—the general congestion in the neighbourhood spreads to the vocal cords, causing hoarseness, "hawking," and even loss of voice. The larynx cannot be seen without the aid of Garcia's mirror, the laryngoscope. No one, therefore, whose larynx is troublesome should be satisfied unless this mirror is employed by his doctor. If it is not used the larynx is not seen, and if it is not seen it should not be treated.

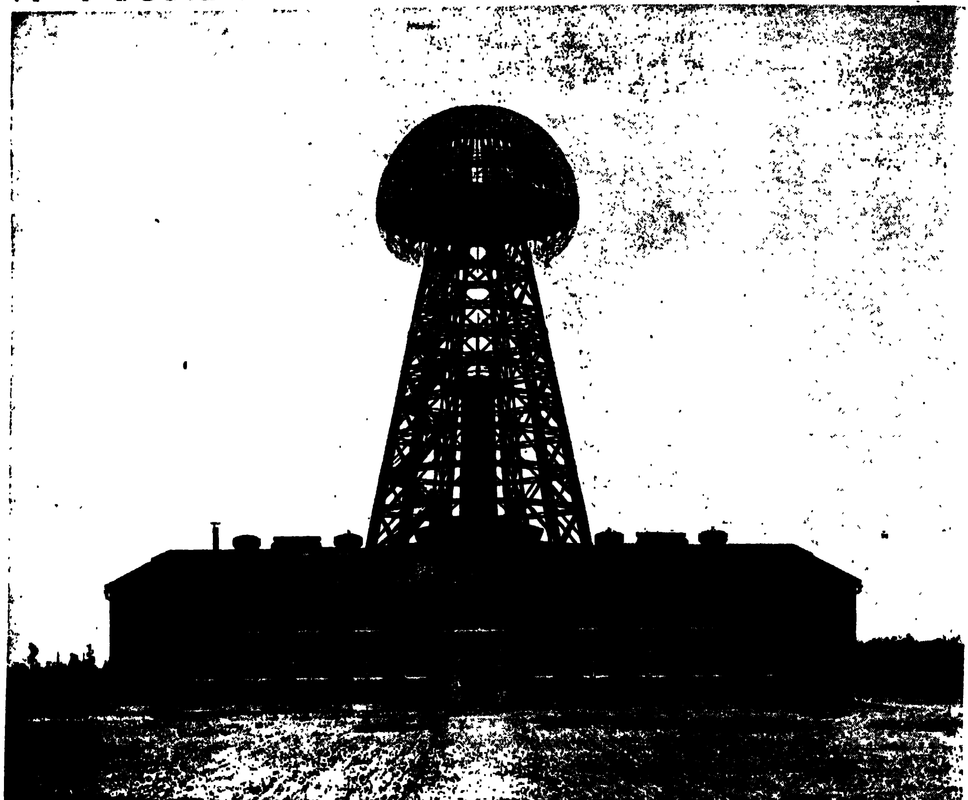
The care of the voice is another question, for which no laryngoscope is required. The inhalation of tobacco smoke has been already discussed. For the rest, let the voice be used in its lower register. Half the secret of having a voice that lasts, and is pleasant and clear, and the use of which is unattended by fatigue, is to keep the vocal pitch low. King Lear described Cordelia's voice as "soft, gentle and low, an excellent thing in woman." Shakespeare had ears, and doubtless knew what it is to live with a high-pitched feminine voice. The shrieking which distresses the ear also hurts the organ which produces it. Members of large families tend to shriek in order to be heard, and occasionally approach the ear-splitting tone which is characteristic of the most envied social functions. The would-be singer or public speaker must avoid this kind of vocal abuse.

Hoarseness a Symptom which Should Never be Neglected

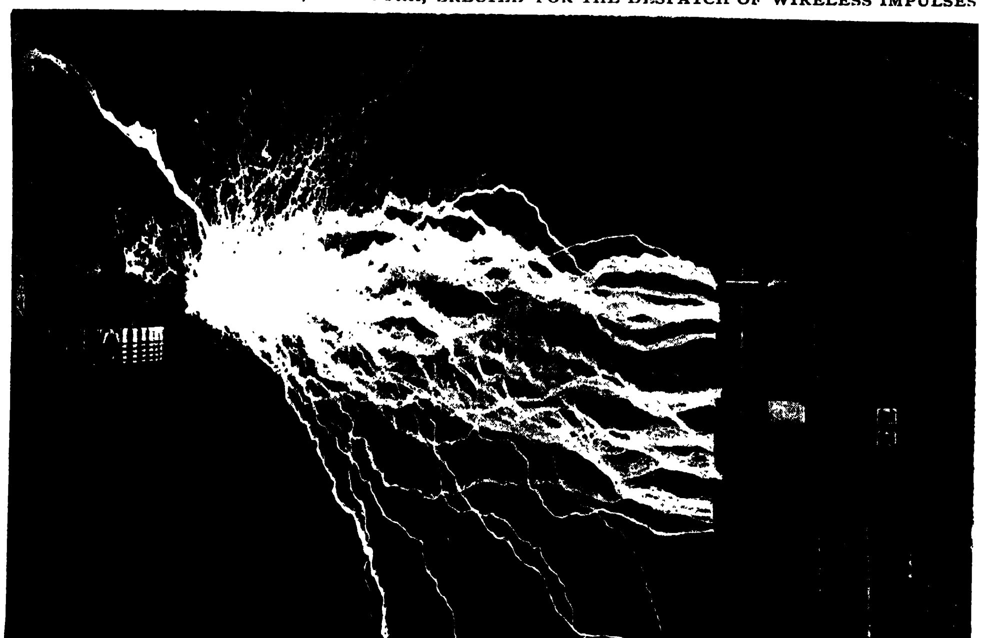
Clergymen are particularly prone to over-use of the voice, *plus* abuse of it, owing to the employment of an unnaturally high pitch for reading and preaching, and "clergyman's sore throat," or chronic laryngitis, is the consequence. For this tiresome malady, rest alone is the sovereign remedy.

Chronic hoarseness should never be ignored. Once its cause is definitely known, there may be little to be done, but no victim of this complaint should be content until at least the cause has been ascertained. He may please himself as to whether he will stop inhaling tobacco, whether he will have adenoids removed, or his nose cleared out. But there are other conditions of which chronic hoarseness may be the symptom. It may indicate nervous disease, or the presence of an aneurism, or enlarged artery in the chest. Again, the hoarseness may be due to a wart or other growth, which can easily be removed, and the voice perfectly restored. Finally, if the growth be of a malignant character, modern surgical methods will often avail to extirpate it entirely and save the patient's life, if not his voice, provided only that, as but rarely happens, the surgeon sees the case in time.

A POSSIBLE TIME-DISTRIBUTING CENTRE



THE TOWER ON LONG ISLAND, NEW YORK, ERECTED FOR THE DESPATCH OF WIRELESS IMPULSES



AN ENORMOUS ELECTRICAL DISCHARGE AT THE LONG ISLAND WIRELESS STATION

MEASUREMENTS OF TIME

The Incalculable Debt We Owe to the Curiosity of the Ancient and Modern Star-Gazer

AN ELECTRIC-WAVE TIME SERVICE

THE sun by day, and the moon and stars by night, send to us something more than the visible light that strikes our eyes. From them comes a subtle radiance which enlightens our minds. It was from the heavens that man obtained that idea of time which was absolutely necessary for the development of his intellectual faculties. He had to find some way of measuring the succession of things before he was able to attempt to control any of them. Isolated at first in the midst of a world in which everything was to him a mystery, and terrified at every unexpected manifestation of natural forces, primitive man was incapable of seeing in the course of the universe anything but caprice.

The alternation of day and night, and the recurrence of the seasons, were no doubt the first thing that enabled man roughly to measure the passage of time. But this carried him very little farther than some animals get. The curious instinct of a recurring change that sends the swallow on its far migrations was not sufficient for intelligent human purposes. Man needed both a finer and a larger instrument for measuring time than the periods of light and darkness, and coldness and warmth, that govern the activities of plant and animal. Compelled by his growing intelligence to search for the reason of things, he suffered great moral and intellectual injury through his long failure to measure time. He could not parcel out space intelligently in the absence of some means of defining the duration of objects ; and his powers of memory were confused by his lack of a fixed standard of the current of events. Being unable to remember distinctly, he was unable to foresee clearly.

It was in this frame of mind that he came to attribute almost every phenomenon around him to the action of a multitude of little fantastic and exacting spirits. And in a vain attempt to control his circumstances he tried to conciliate the supernatural powers by means similar to those that one employs to win the good graces of a powerful Minister. It is almost impossible for us to put ourselves into the state of mind of a human being with no means of measuring both the small and the large passages of time. It is a mental condition of hysterical emotionalism that would have something of madness in it to a man who knew what the account of time was. Even the lowest of modern savages has not remained at so primitive a mental stage as this, but there are abundant traces in their religious and magical practices which show that a timeless world of utter chaos was but too well known to their remote ancestors.

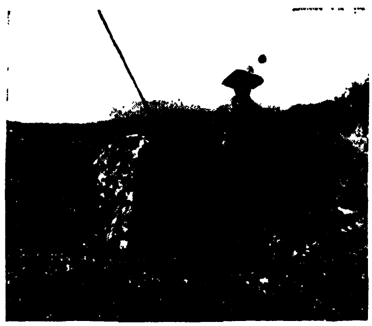
It was by the study of the recurring phases of the moon that primitive man seems to have made his first great advance. By lunar months a good many uncivilised people still measure the longer lapses of time. It was more difficult to find a way of dividing a single day into small, regular periods. For the daily course of the sun from the eastern to the western horizon varies considerably in most parts of the earth. The rising point and setting points are quite different in winter and summer, and the course of the low winter sun is much shorter than that of the high summer sun.

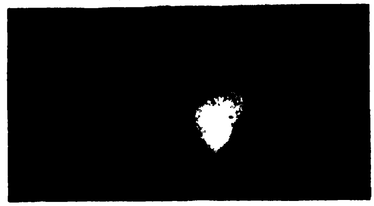
The shadow thrown on the ground by a tree or an upright stick does not travel over equal distances at an equal speed. So this primitive form of sun-dial was not useful as a teller of the passing hours of daylight. It was not until man grew studious of the spangled darkness of the midnight skies, and began to study them on clear, unclouded nights, that he obtained that vision of a reign of universal law which he could not discern on the earth around him.

On considering the midnight sky attentively, he perceived that the stars were not a confused multitude of lights wandering at a venture, but a disciplined army that marked by its march the regular passage of time. Against this majestic revolution of the heavenly sphere, with its awe-inspiring regularity of motion, the different annual courses of both the sun and the moon stood out clearly. As soon as the star-gazers gave themselves up to their work, they discovered that the sun could be regarded as the hand of a yearly clock, that showed by its position in the celestial track the month and season. Of course, it was impossible to observe the sun and stars at the same time, and it would have been much easier to have studied the moon alone as the clock-hand. But in scarcely any case of which we know anything was this done. The sun's path among the stars was divided into twelve portions, each corresponding with fair approximation to a month.

Two methods were then used in ascertaining the time of the year. Some early astronomers rose up before dawn, and made observations of the last conspicuous star rising just before the sun. The other school of time-measurers did their work in the evening, and associated the sun with the constellation that set just after sunset. After mapping out the constellations, directly associated with the yearly and monthly course of the sun in the skies, it was a simple step to study a few other star groups in other parts of the heavens. In the south there were some very bright stars, whose risings and settings gave an indication of the time of year; while in the north there were many stars that did not set at all so that their slow motion had a special value for the night-farer and the sailor.

All this was done in widely separated parts of the earth—in Babylonia and in Egypt, in India and in China, among the Incas of Peru and the Aztecs of Mexico. The South Sea Islanders and the ancient inhabitants of Britain both worked out the astronomical method of measuring time; and so did other barbaric and even savage races. Whether the great work of thus rescuing mankind from a world of timeless chaos and placing him in a universe of heavenly law was performed by some single nation of civilising genius whose discoveries were gradually spread among other people; or whether the common result was obtained independently at different times by different peoples is a problem that cannot be solved. There are, however, some good grounds for supposing that the Egyptians, Indians, and Chinese have made false claims in regard to the immemorial antiquity of their astronomical studies.



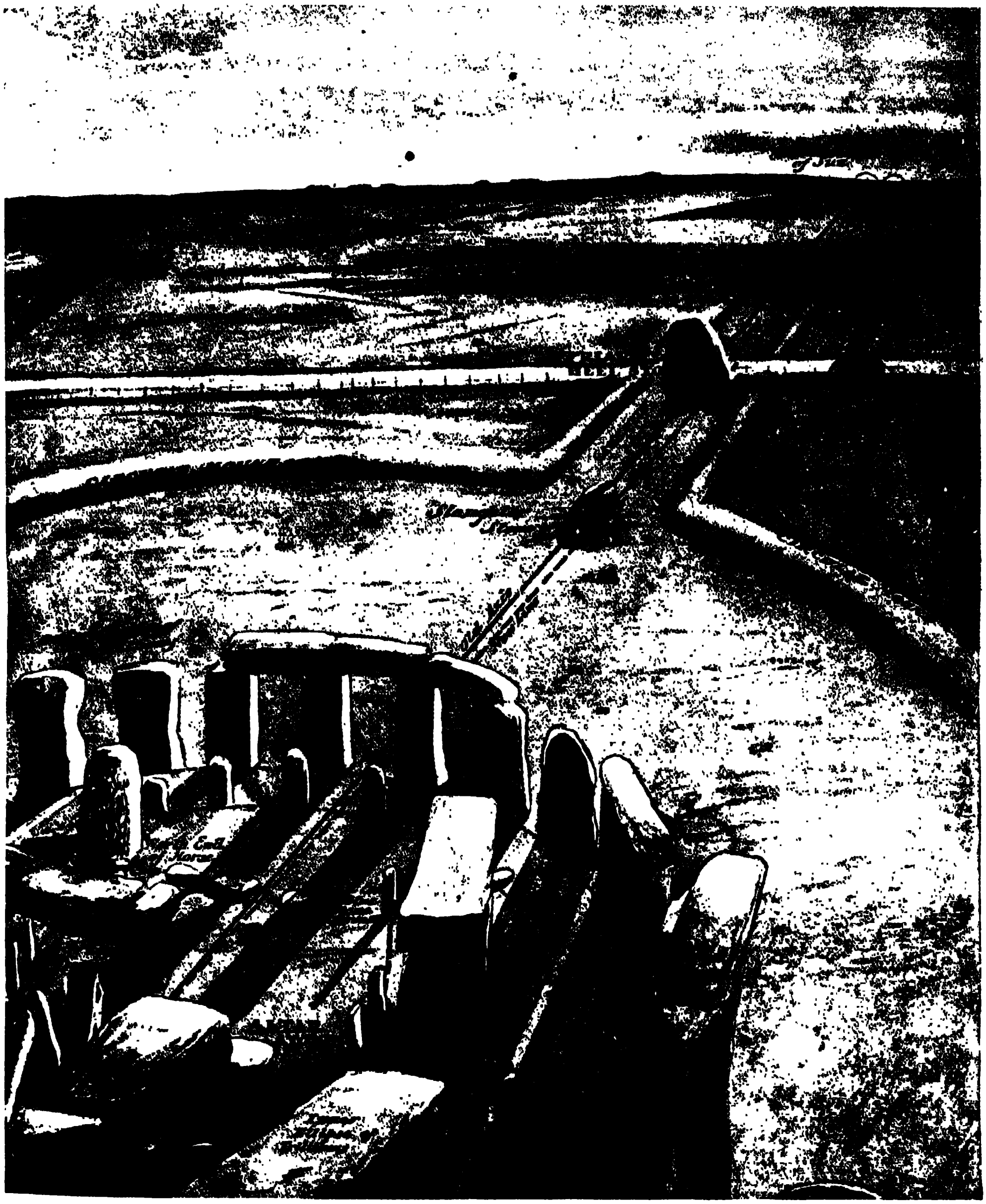


TIME-MEASUREMENT IN PREHISTORIC DAYS

The lower photograph shows the Bridestones, at Camp, from the E.N.E., that on the right marking the sunrise at the summer solstice. The hours are marked by shadows touching various prominent points or edges of the stones at the equinoxes, the winter solstice, and at the beginning of November and February. The top picture shows that the south stone has an angle equivalent to that of the summer solstice, and the middle photograph shows the sun passing across a notch at the meridian on the winter solstice. These three pictures are from Dr. A. M. McAldowie's paper in the Transactions of the North Staffordshire Field Club, 1912.

On the other hand, the system of the Babylonians stands examination, in spite of the fact that the Babylonian priests modestly informed Alexander the Great that their astronomical records went back 403,000 years. For it seems highly probable that about four thousand years ago the early inhabitants of Babylonia fixed and named the chief constellations that mark the annual path of the sun. The star groups which were afterwards added were too far south of Babylonia to be visible in 2000 B.C.;

and the period that elapsed before they were included in the modern method of measuring time is a piece of striking evidence in support of the claims of the Babylonian star-gazers. There is even some truth in their contention that their astronomical calculations extended back for over 400,000 years. With the knowledge they amassed concerning the sun's apparent path through the heavens, they worked back and verified, to within a few years, the solar position, such as would be indicated on a sun-dial.

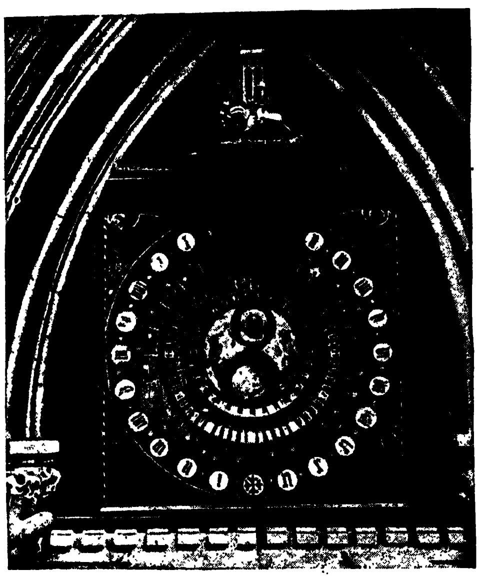


THE MYSTERY OF STONEHENGE AND ITS ASSOCIATION WITH TIME

This picture-diagram shows how the sun's rays fell on the sacrificial stone at Stonehenge on midsummer morn 4000 years ago and in the beginning of the twentieth century. Sir Norman Lockyer roughly calculated that Stonehenge was erected 1700 years B.C., by calculating the divergence of the sun's rays from the centre line through the Friar's Heel Stone and the axis of the temple, the sun having shifted his apparent position, due to the tilting of the earth, which is known to be 48 seconds of an arc every century.

The invention of a proper sun-dial was

only possible among a nation with a knowledge of the sun's apparent movements against the starry sphere; and it is possible that the Babylonians accomplished it. It is only at the North and the South Poles that a stick stuck upright in the ground will indicate by its shadow the regular passage of the daylight hours. In lower latitudes the shadow cast by the upright rod or style of a sun-dial would so alter its position at the same hour, at various seasons of the year, that the instrument would be useless. For instance, at nine o'clock on a midsummer morning the shadow would fall a good distance away from the spot it would occupy at nine o'clock on a midwinter morning. So the marks on the dial would be very misleading. To make a proper sun-dial, it is necessary to calculate the different paths that the sun takes in its high summer course through the sky and in its low winter journey. It is easily done by giving the rod or style of a sun-dial the same direction as the axis of the earth. This sounds very abstruse and difficult, but in practice it only means that the style should point to the Polar Star. The position of its shadow in the sunlight will not then alter with the varying path of the sun. The shadow at nine o'clock on a sunny winter morning will fall upon the same line as the shadow falls on a bright summer morning. The task of drawing the hour-marks on a dial is more difficult, as these occur at irregular intervals, instead of being evenly spaced round the dial.



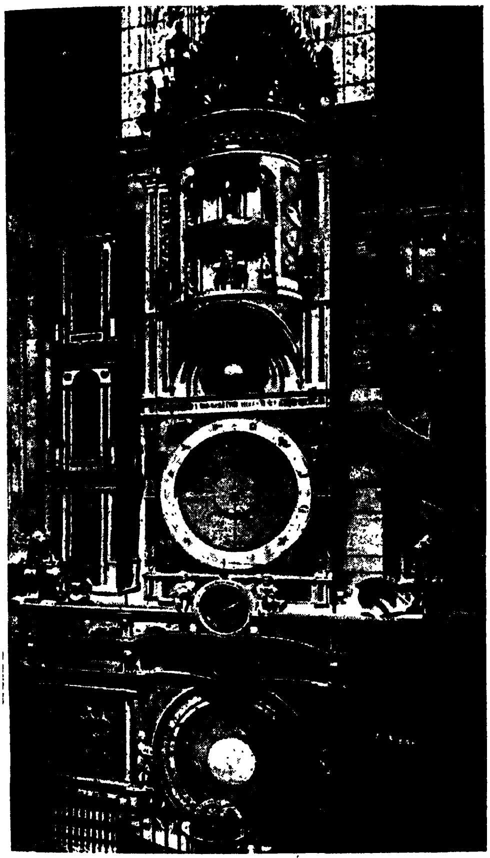
THE CLOCK THAT WENT FOR 500 YEARS AT GLASTONBURY ABBEY

But the savages who lived in prehistoric times in Great Britain seem to have worked out part of the difficult art of making a sun-dial. A few months ago there was published in " Nature " an abstract of some results of the excavations that Dr. McAldowie recently made in prehistoric burial mounds in Staffordshire and Gloucestershire. Near his own home, at Camp, the doctor has uncovered a huge, rough stone monument, which clearly seems to be a very ancient instrument of time measurement. It consists of four stones, placed north, south, east, and west, and embedded in the solid rock. A leaning stone crosses in a diagonal manner the space formed by the outer stones. The structure is so built as to mark the turning points in the sun's annual path; but its most interesting feature is the way in which the hours are indicated at certain times in the year by shadows falling on prominent points or edges of the monument. The north stone is really a sun-dial, and the south stone a style, while the east and diagonal stones fulfil both purposes. The structure thus appears to have been a sacred instrument used for measuring the time at certain critical periods of the year, some of religious and some of agricultural importance. Dr. McAldowie has lately uncovered several other burial mounds, and found beneath them other big, rough stone dials. He thinks they were the sacred places or temples of a very early race, and that they were converted into burial mounds by some alien invaders who took over, as is often the case among ancient races, the traditions of sanctity attaching to the monuments.

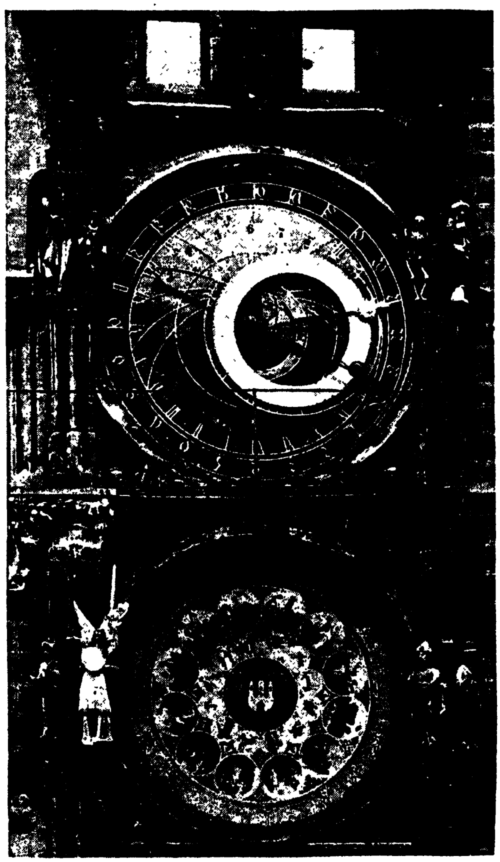
It scarcely seems possible that these buried structures should all by mere chance be admirable sun-dials. The real question is whether they are later in date than Dr. McAldowie supposes. Our own opinion of the matter is that many so-called Druidical remains in our islands were in existence before the Celtic peoples and their medicine-men, the Druids, invaded the country. The Druids no doubt, took over the traditions of sanctity attaching to Stonehenge and Avebury, and other similar prehistoric monuments; and it is quite likely that in some cases they may have continued, and improved upon, the work of the earlier builders. But on the whole we think that most of these strange monuments were the work of a native, non-Celtic people of the

New Stone Age, whose descendants still form a considerable element in our population. It is possible that this prehistoric British race was not far behind the civilised farmers of Southern Babylonia, in marking the annual path of the sun amid the stars, and putting their knowledge to good use in the erection of strange, rough, open-air temples that partly served as sun-dials. We can scarcely conceive how bitter was the need, among nations struggling into the agricultural state, of some means of measuring time, and thus discerning the approach of the sowing season and the coming of the harvest. The huge, rough sun-dials that indicated the divisions of religious and prehistoric times, and marked the solar hours at certain periods, may well have become the centres of both tribal and inter-tribal life.

Thus it perhaps came about in the New Stone Age, when a knowledge of farming was spreading throughout Europe, that the men who designed and looked after the primitive sun-dials ranked next in importance to the royal chiefs. Indeed, in the course of time they grew so powerful that the chieftains liked to appoint members of their own families to the position of religious time-measurers. The work that the star-gazing wizards of Stonehenge probably used to perform has not lost any of its importance in the lapse of centuries. Their successors are now members of his Majesty's Civil Service at the Royal Observatory, Greenwich, and at the Nautical Almanack Office in Gray's Inn Road. Were the staff belonging to either establishment to cease work, the country to a large extent would come to a standstill. Our shipping especially would suffer. Our sailors would have to go back to the principles of navigation that were employed two thousand years ago, feeling their way from place to place by daylight and keeping to the coast. Long voyages could only be executed at great



THE CLOCK AT STRASSBURG CATHEDRAL



THE ASTRONOMICAL CLOCK AT PRAGUE

peril. Moreover, our railway system would be disorganised. A few trains could run, but only at considerable intervals, and they would have to travel by daylight and at low speeds.

A clockmaker would not be able to save the situation. Clocks are extremely useful in their way; but it is a grave mistake to regard them as the fundamental basis of time measurement. They only deal with seconds, minutes, and hours. In the last resort we have no better means of measuring the lapse of years than the early Babylonians discovered forty centuries ago. The clear night sky, with its majestic array of stars, is still the timepiece by which we measure the duration of all things. Our clocks and watches are conveniences: the work of the astronomer is an absolute necessity of human life. In taking transit observations the time that it takes him to make a signal with his hand, as his eye watches a certain star, is the limit of accurate time measurement. One-fifteenth of a second is generally reckoned to be the limit of accuracy in personal observation: for the most rapid pianoforte player, whose rapidity of execution is the result of years of finger exercise, cannot strike a note more than twelve times a second. No doubt it is easy to build a machine that would divid a second into a hundred or more parts Indeed, chronographs for dividing an measuring one-thousandths of a second ar used in the nev scientific study o motion. But n astronomer coul check an instru ment of this sort The very best h can do is to kee an astronomica clock regulated t one-thirtieth of a second, and the only by means o frequent transi observations.

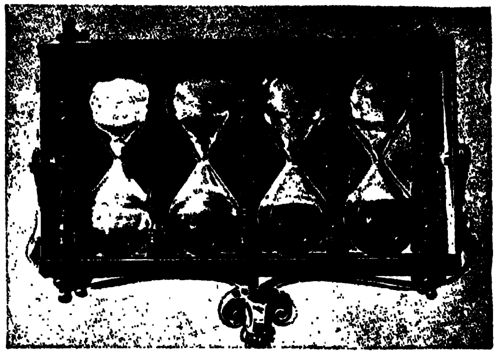
A TWELVE O'CLOCK HOUR-LINE IN A PARIS CHURCH

The upper picture shows the round hole in the south window of St. Sulpice Church, Paris, through which the sun's rays at noon pass, to cross a copper band set into the floor and carried up the obelisk on the north side, shown below. This line formed the official meridian line of France prior to the adoption of Greenwich time. Its course is marked white on the picture, and its length is due to the difference in the height of the sun at the summer and winter solstices.

No clock tell the time exactly It is merely a mechanism fo giving an approxi mate measure ment of th duration of things And it can onl work properl when it is regu lated by the obser vations which an astronomer make on the movement of the stars. S in most of th principal observa tories of the worl astronomical ob servations ar made on ever clear night, fo the express pur pose of regulatin an astronomica clock with th greatest exactness Then every day a noon a signal i sent to variou parts of th country by tele graph, so that a persons who hea the signal ca regulate their clock within two or thre seconds. These signals also can be used t correct clocks automatically, putting the forward if they are too slow, and settin them back if they are too fast, by a simpl

TIME RECORDERS IN CLOCKLESS AGES

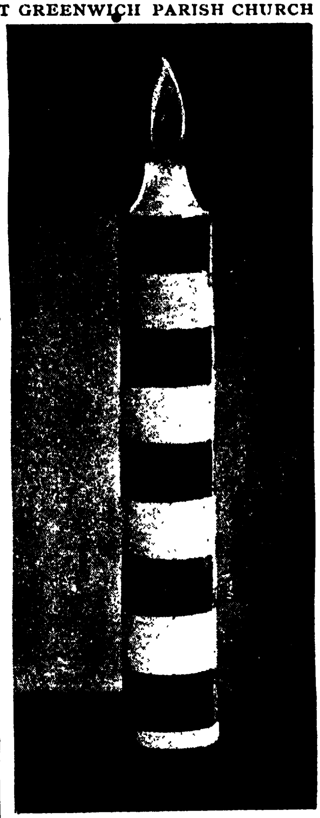
TELLING TIME BY WATER-FLOW



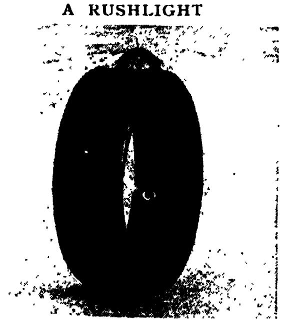
HOUR-GLASSES AT GREENWICH PARISH CHURCH

A RUSHLIGHT

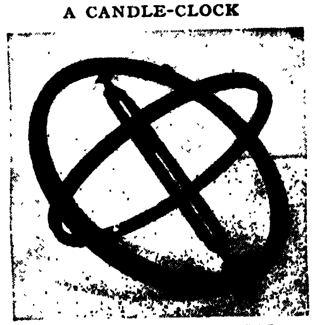
THE WIMBORNE SUN-DIAL



A CANDLE-CLOCK



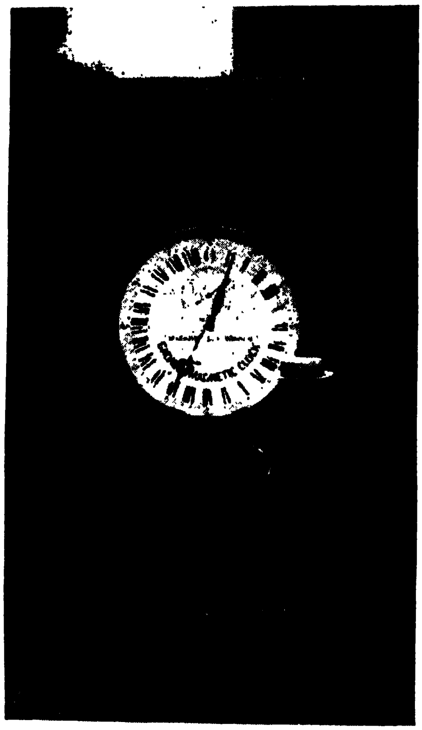
A POCKET SUN-DIAL



A PORTABLE SUN-DIAL

electro-magnetic device called a "synchroniser." This is the way in which exact time is maintained in all large cities throughout the civilised world. In London the Standard Time Company have provided an hourly service of synchronising signals since 1878, and his Majesty's Government are at last permitting the use of their vast network of telegraph wires for this purpose throughout England. The railway service specially owes an incalculable debt to the time-keeping astronomers, who daily check, by the apparent movement of the starry sphere, all the principal clocks in the world, and thus enable railway trains to be run with a safety and exactness that no kind of clockwork could maintain.

The daily revolution of the earth with regard to the sun is not uniform. As is well-known, it is midday at the instant when the sun is seen at its greatest height above the horizon. But this takes place sometimes 16 minutes 18 seconds sooner, and at other times 14 minutes 28 seconds later, than twelve o'clock mean time. These curious variations are due to the fact that the earth not only has a daily revolution with regard to the sun, but that it advances at the same time along its annual path, moving with greater rapidity when it is near the sun in December than it does in July, when it is farther from the centre of the solar system. The regularity of the earth's motion is also further disturbed by the attraction of the moon and some of the planets. So a sundial in the best of order is a very incorrect timekeeper; and if we had to rely entirely on observations of the sun, many of the main activities of our civilisation would be sadly disordered and ill regulated.



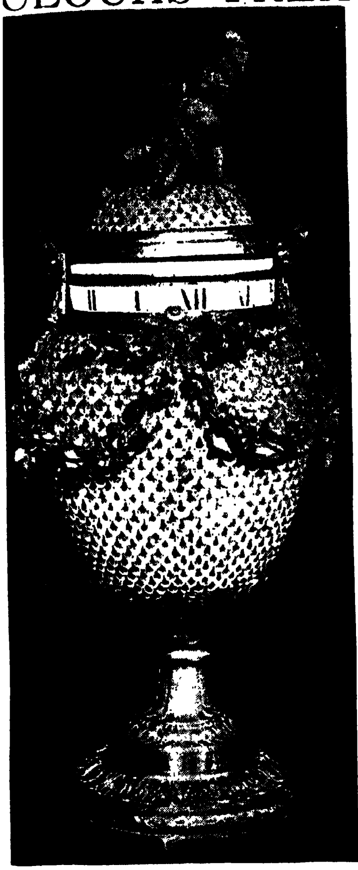
THE CLOCK AT GREENWICH WHICH SHOWS STANDARD TIME TO THE WORLD

On the other hand, the daily spin of the earth with regard to the fixed stars in the remote depths of space is uniform. The distance between our earth and the constellations is so immeasurably great that the variations in the position of our planet in its annual orbit are of no practical account. A star will always appear at its meridian 3 minutes 56 seconds sooner than it did on the preceding day. It is a fairly easy matter to regulate the clocks of one's household by observation of the stars; and we would commend any reader, interested in timekeeping, to measure by the stars, instead of putting up in his garden a picturesque but irregular working sun-dial. A transit instrument and a table giving the right ascension of the particular stars lighten the labour of observation, but neither is absolutely necessary.

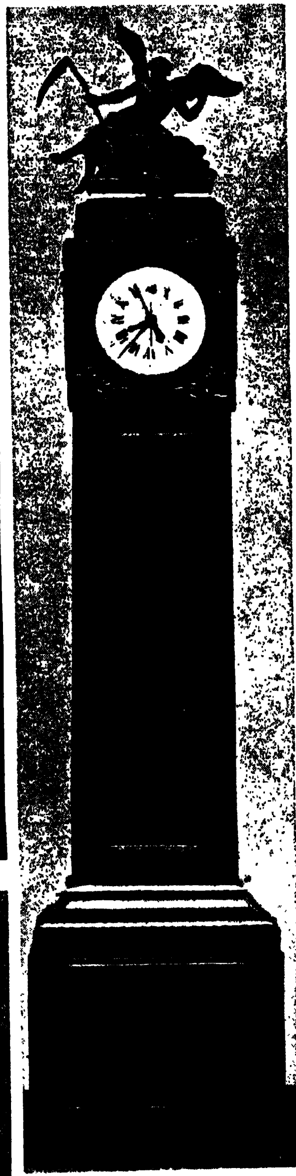
As an experiment, choose a window having a southern aspect, from which the steeple of a church, or a tall chimney, or some other fixed point may be seen. To the side of the window attach a thin plate of brass, having a small hole in it, so that, by looking through the hole towards the edge of the steeple or other fixed point, some of the stars may be seen. Watch the progress of one of these, and at the instant it vanishes behind the fixed point make a signal to the person observing the clock, who must then note the exact time at which the star disappeared. On the following night the same star will be seen to vanish behind the same fixed object 3 minutes 56 seconds sooner. If the clock does not show this, the clock is wrong, and must be put right.

If a series of cloudy nights should then make it impossible to compare the clock with the stars, it is only necessary to multiply 3 minutes 56 seconds by the number of days that have elapsed since the last observation and record were made. Deduct the product from the hour which the clock then indicates, and this will give the time the clock ought to show. The same star can only be observed for a few weeks. For as it gains nearly one hour in the fortnight, it will at last reach the meridian in daylight, and become invisible. To continue the observation, another star must be selected and

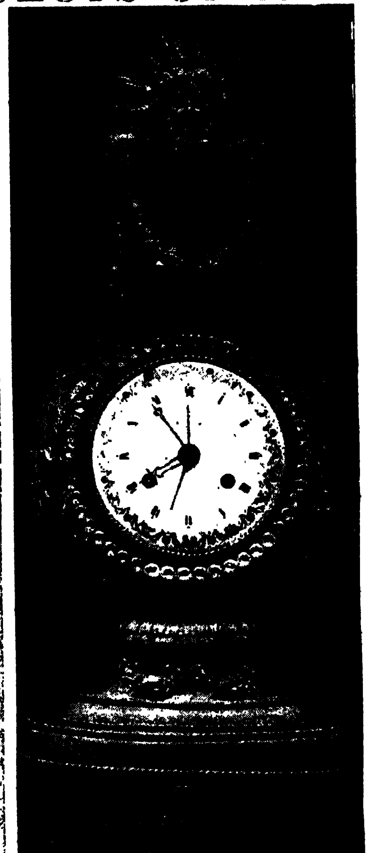
CLOCKS TREATED AS OBJECTS OF ART



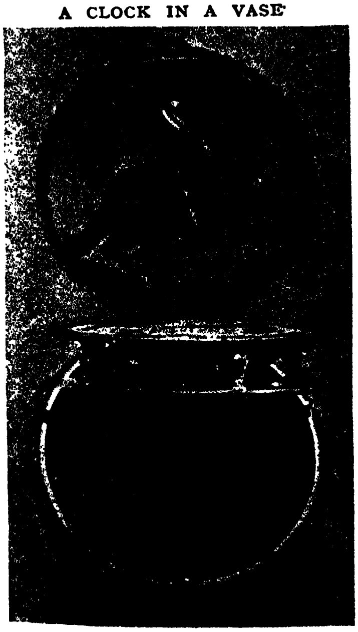
A CLOCK IN A VASE



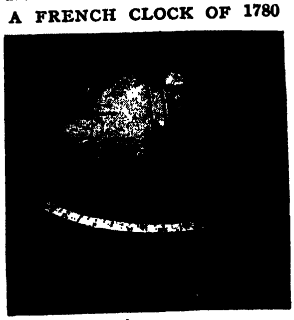
A FRENCH CLOCK OF 1780



A CLOCK OF SÈVRES PORCELAIN



A WATCH OF LOUIS XIV.



A WORLD'S-TIME CLOCK

ALL GLASS EXCEPT THE SPRING

studied through the hole in the brass plate. Care must be taken that a planet is not chosen instead of a star. As is well known, most of the planets appear larger than the stars, and give a steady reflection, instead of a twinkling light. But the surest means of distinguishing between them is to watch a star attentively for a few nights; if it changes its position with regard to the other stars, it is a wandering and misleading planet.

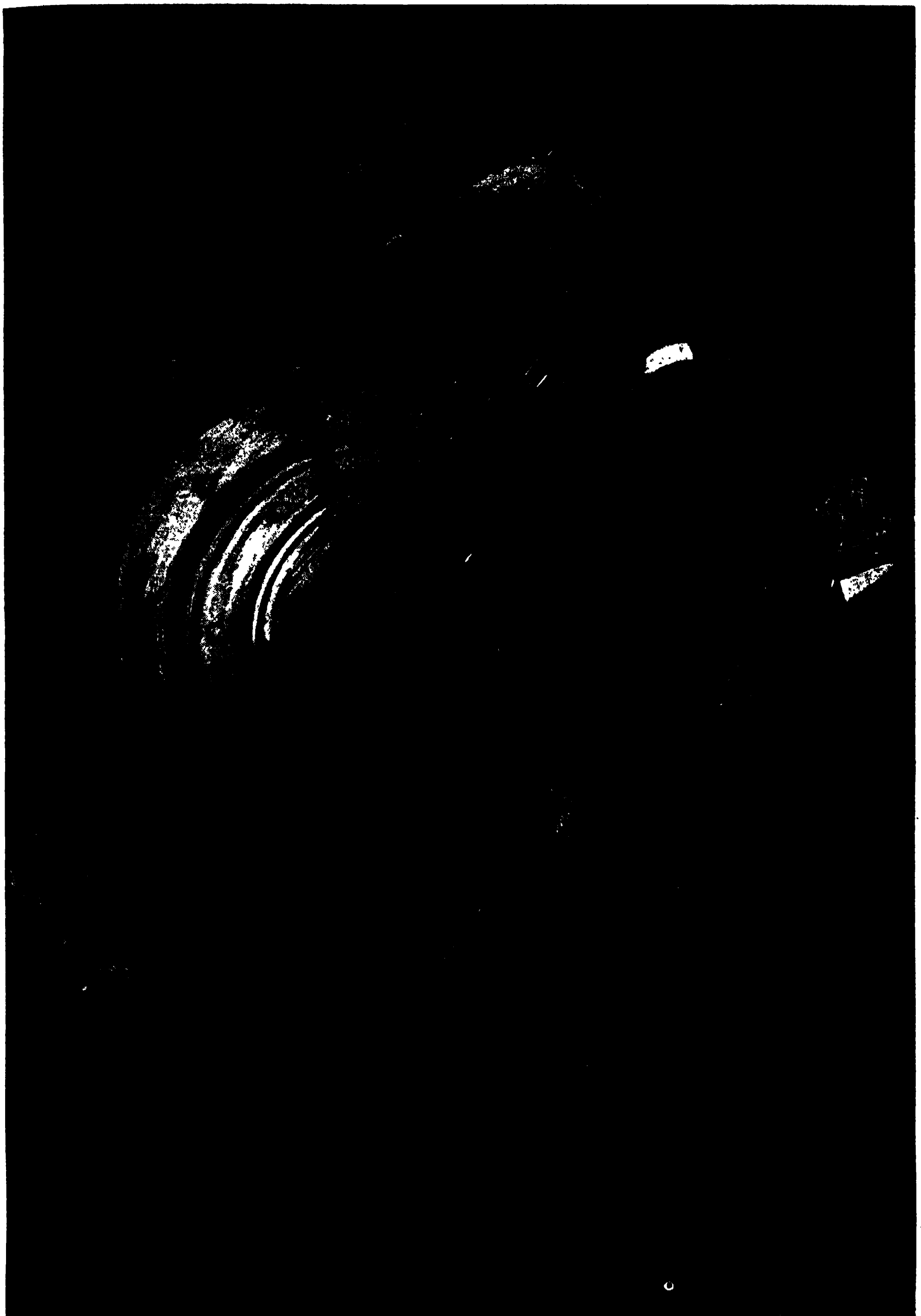
THE HANDS OF ONE OF THE BIGGEST CLOCKS IN THE WORLD—THE COLGATE TIMEPIECE, NEW YORK
The minute-hand of this clock measures 20 feet, and the diameter of the face is 38 feet. This measurement is, however, eclipsed by that of the clock at the Crystal Palace, which measures 40 feet.

Of course, an astronomer uses more precise methods of measuring time than the rough and handy sort of observation which we have described. But we hope our description has clearly brought out the fundamental fact that all time measurement still depends entirely on the personal observation of the movement of the earth in regard to the stars. Every observatory in the world has its transit instrument, which is a fixed telescope on a stated meridian, with a spider's thread across its field. For at least four thousand years the universe has been our clock; and our fundamental clock it will remain, however much all our modern mechanisms for measuring time may be elaborated and made automatic.

A SURVIVAL OF THE DAYS OF BAD DOMESTIC TIME-KEEPERS—THE FIRING OF THE MIDDAY GUN

The astronomers who measure our time for us are now being equipped with a cheaper and handier method of signalling the results of their observations than the telegraph wire. The invention of the electric-wave systems of wireless telegraphy is destined to have a far-reaching effect upon the general methods of keeping time; and may be actually used to operate circuits of electrically propelled clocks. All that is needed is a sensitive detector which, when affected by the electric waves from a distant transmitting station, allows the current from the local battery to act. This local current, on coming into play, moves the minute-hand of one or more dials a step forward; or rather it moves the wheel that moves the hand, each movement of the wheel affecting the mechanism regulating the position of the hour-hand. Thus the elaborate works of an ordinary clock or chronometer are unnecessary. This is the great contribution to the service of world-wide timekeeping which

MEASURING THE TIME BY THE STARS



THE LARGE TELESCOPE USED AT GREENWICH OBSERVATORY. THE UPPER TUBE IS USED FOR OBSERVING THE STARS, BY THE APPARENT MOVEMENTS OF WHICH IN THE HEAVENS EXACT TIME IS MEASURED. THE LOWER, LARGER TUBE IS USED FOR SOLAR PHOTOGRAPHY

will be made by the twentieth century. On its very threshold, in the year 1900, Mr. F. Hope Jones, an electrical engineer prominently associated with the application of electricity to horology, experimented with wireless on a series of clocks, adapting his system, illustrated on page 3731, for this purpose. The difficulty at that time was the liability of time-receivers to interference from other electrical oscillations in their neighbourhood. The discovery of "tuning" has largely done away with this interference, but not entirely. A certain periodicity of electrical oscillations will have to be set up and devoted solely to the time-signal, and it would have to be made a criminal offence for any unauthorised person to queer the time, as it were. A few months ago a young English inventor claimed that he had overcome the bugbear of interference, and discovered a means of actuating all the pocket watches of the nation, by means of electric waves radiated from some central station, such as Greenwich Observatory. In the case of a watch, of course, it would be a practical impossibility to use a detector that brought into operation a local current. The electric waves themselves would have to be powerful enough to affect the indicating apparatus. It is said that this has been achieved, with the result that a central time-keeping station could actuate, by means of electric waves, both the clocks and the watches [illegible] some hundreds of miles. We are told [illegible] inventor that the receiving mech[illegible] he has designed for a watch would act in any position within the radius of transmission.

It would work when the watch was placed under the pillow at night, or carried in the pocket in a train at daytime. If this were so, a very great advance in electric-wave transmission would be accomplished; but we must confess that we are somewhat doubtful of the matter.

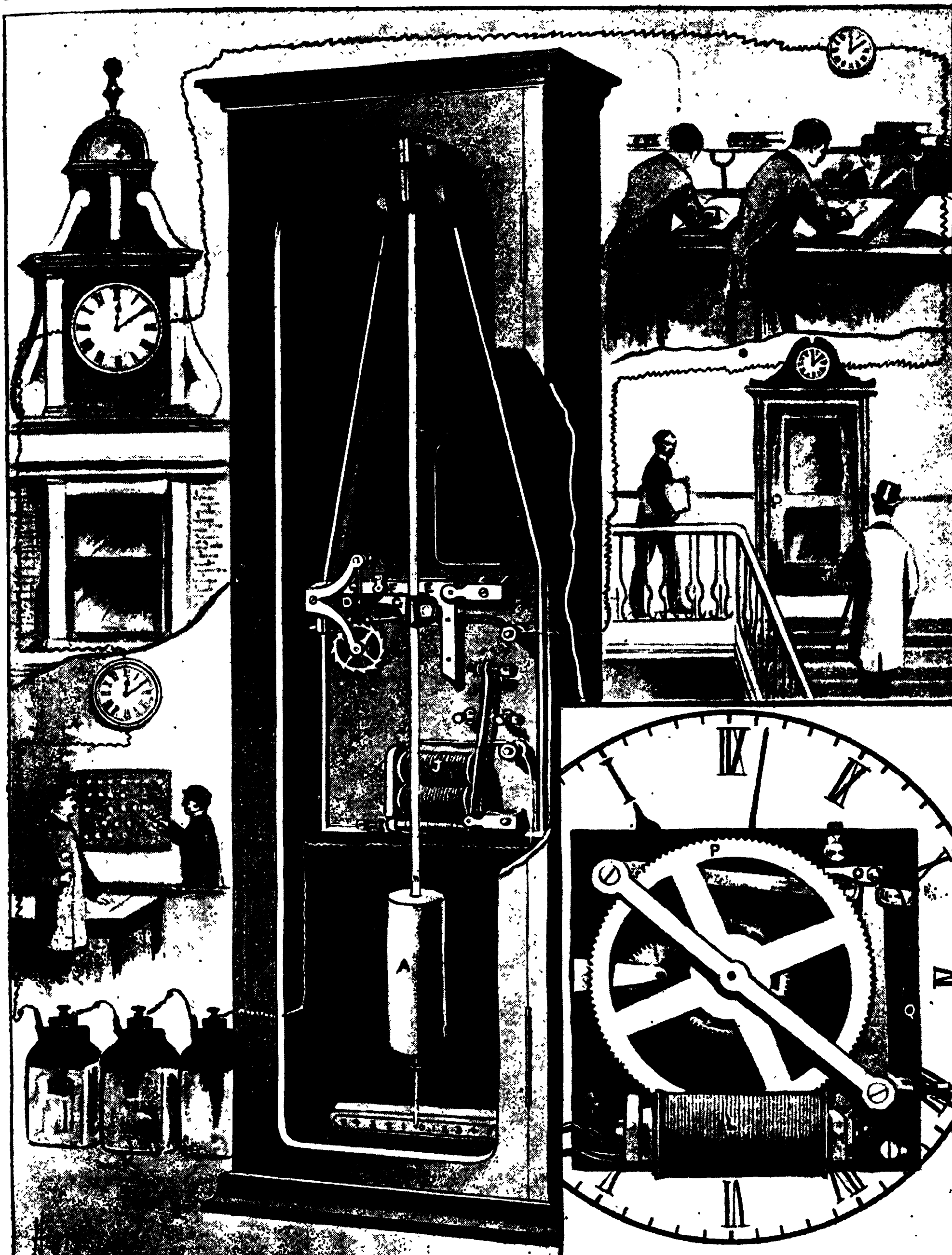
So we think that, in the immediate prospect, only the clockmaking industry is partly menaced by the new league between the astronomers and the electric-wave engineer. In all probability only the timepieces of a few large corporations and wealthy private subscribers will at first be kept going by the wireless transmission of electrical power from some observatory. Not until it is greatly cheapened will the new service be available for household use.

SHIP'S OFFICERS TAKING THE SUN AT MIDDAY IN MID-ATLANTIC BY MEANS OF A SEXTANT

It has been pointed out, however, that the cost of keeping one single clock going at a long distance from the central station is not in any way increased if some millions of clocks are worked by the same station.

The expense is incurred in making the nocturnal observation of the stars, and regulating an astronomical clock in accordance therewith, and then connecting this clock with the transmitting instrument of a wireless signalling apparatus. The electric waves then go rippling outward at all points of the compass. It is just as easy for them to affect the receivers of ten million clocks as it is for them to keep a single clock, a hundred miles away, working. There is only the additional prime cost of constructing the million of electric clocks, with their receiving instruments. These could either be bought by the subscribers or let out to them on hire; and as all the parts would be standardised and made by machinery, each clock would cost but very little. So there is a great likelihood of the wireless time service developing in the end into an inexpensive, as well as a most exact, trustworthy, and

MANY CLOCKS WORKED BY ONE PENDULUM

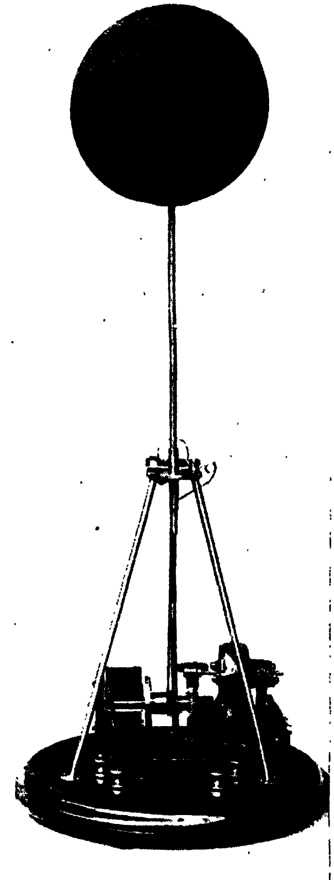


HOW AN ELECTRICALLY DRIVEN PENDULUM TURNS THE HANDS OF NUMEROUS DISTANT DIALS

By the aid of the electric current all the clocks in a large factory or even a town can today be controlled by a single pendulum. This diagram shows the principle of the synchronome system. The clock consists of the pendulum (A) alone, which pulls round the wheel (B) once every half-minute. The vane (C) then withdraws the catch (D), and allows the gravity lever (E) to fall. The little roller (F) presses the pendulum aside by running down the bracket (G) mounted upon the pendulum. The lower arm of the gravity lever (E) then meets the contact screw in the end of the armature (H), thereby closing the circuit of the electro-magnet (J), which allows the current from the battery (K) to pass through the dials all over the building. These dials are advanced half a minute whilst the electro-magnet (J) attracts the armature (H) and throws the gravity lever (E) up on to its catch again. The clock-faces have no "works" behind them, only one wheel and a magnet, shown on the right. The electro-magnet (L) receives the half-minute impulses, so attracting the armature (M), and by means of the lever (N) enabling the click (O) to pick up another tooth of the wheel (P). The spring (Q) then propels the wheel (P), and the minute-hand attached to it, one half-minute. This picture and those on pages 3732-3 are by courtesy of The Synchronome Co.

convenient system. How quickly it becomes a fairly general necessity depends largely upon the capital and the enterprise of the various companies that are beginning to engage in its application and development. And no doubt the genius of many an inventor will tell on the final result. The one practical service which wireless telegraphy has already rendered is the distribution of time-signals for the benefit of shipping, notably from the very powerful transmitting station on the Eiffel Tower. These signals can be heard only; they cannot be used to correct a clock automatically, or to propel it.

In the meantime, the extraordinary amount of science and ingenuity which has gone to the making of our mechanical timepieces deserves a brief consideration. A first-rate chronometer is one of the most interesting and useful of mechanisms. By means of it the captain of a ship is able to perform a calculation similar, but opposite, to that which astronomers make for us every night. The astronomer knows, when he undertakes a measurement of time, the exact position he occupies on the surface of the earth, and the exact position in the skies of the heavenly body that he is studying. This enables him to calculate exactly the correct time. The mariner, on the other hand, knows from his chronometer what the time is to within a fraction of the truth; and he is then able to learn, by an observation taken with an instrument he carries, his exact position on the ocean. At noon, by means of an instrument called a sextant, he measures the angle at which the sun is at its highest above the horizon; and knowing from his Nautical Almanac at what angle the sun is above the equator, he can quickly calculate the latitude of his ship—that is, how far north or south it is.



AN AUTOMATIC TIME-BALL THAT SIGNALS EVERY HOUR

This is a model of the ball erected by the Synchronome Company on top of a lofty dome in Kingsway, London. It is raised to the top of the mast at a quarter before each hour by means of an electric-motor which operates automatically. It is dropped precisely at each hour by electric current from Greenwich Observatory. It is the only automatic time-ball in the world.

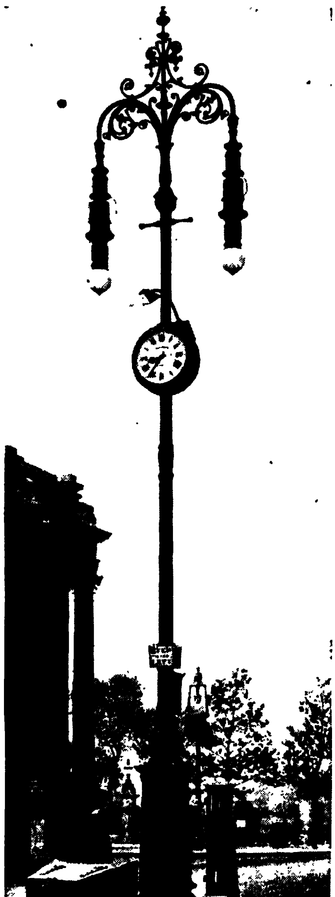
But in order to find out his longitude—that is, how much east or west he is of Greenwich—he must have a chronometer that keeps Greenwich time.

If his watch is two minutes out, he will miscalculate the position of his ship by half a degree of longitude—that is to say, by thirty geographical miles. For the earth takes two minutes to revolve that distance. In the reign of Queen Anne an Act of Parliament was passed offering a reward of £20,000 to any inventor who could find a method of telling the longitude at sea true to half a degree. A Yorkshire carpenter, John Harrison, worked at the problem for forty years, and at last won the reward by making a watch that did not lose more than two minutes in a period of several months. This will show of what incalculable value an exact means of measuring time is in ocean transport. The sun and the stars by themselves cannot help a sailor to find his time and longitude at sea, for naturally he has no fixed and settled point at which to observe them. Unless he can keep in touch with some observatory by means of electric waves, he must trust to his chronometer. Yet wireless telegraphy is now making such swift and gigantic strides that, as we write, news comes from the International Time Conference that by July, 1913, wireless time-signals will be transmitted over half the globe.

The first mechanical device for measuring the daily lapse of time was the water-clock that was used by the Babylonians and Egyptians and other ancient nations around the Mediterranean. It consisted of a basin with a spout or tap from which water trickled into a receiving vessel. On the inside of the receiving vessel were marks from which the hours could be told by the

height of the water. In the course of time this simple mechanism was greatly improved —especially by the Greeks. The receiving vessel became a long cylinder, in which a float was placed. Connected with the float was a chain passing over a pulley on a spindle, and balanced at the other end by a weight. To the pulley was fixed an hour-hand, which pointed out the hours on a dial, as the float rose on the water. The energy obtained from the rising water by means of a float or some other contrivance was sometimes used to work mechanical figures, instead of being employed to move an hour-hand over a dial. About eleven hundred years ago the King of Persia sent Charlemagne a water-clock of bronze, inlaid with gold, which was very ingeniously constructed.

The dial was composed of twelve small doors, representing the hours. Each door opened at the hour it represented, and out of it came a number of little balls, that fell one by one at equal intervals on a brass drum. The hour of the day was shown to the eye by the number of doors that were open, and the ear was informed of the time by the number of balls that fell. At twelve o'clock, a dozen miniature horsemen issued forth and closed all the doors. At the time when this Oriental marvel was still being displayed in France, our King Alfred made a simple clock by which, at night-time, he could both write and tell the time. For it was simply a long, thick, slow-burning candle, with the hours that it took to burn marked upon it. The sand-glass that careful housewives still use in boiling eggs was also employed for some thousands of years in marking the time. The Chinese and Japanese used to make a primitive timekeeper out of a wick of flax or hemp, about two feet in length, and knotted at regular intervals. The wick was specially treated so that, when lighted, it would slowly smoulder away without flame, and the time was estimated from the unburnt portion.



A FORERUNNER IN MUNICIPAL TIME-SERVICE

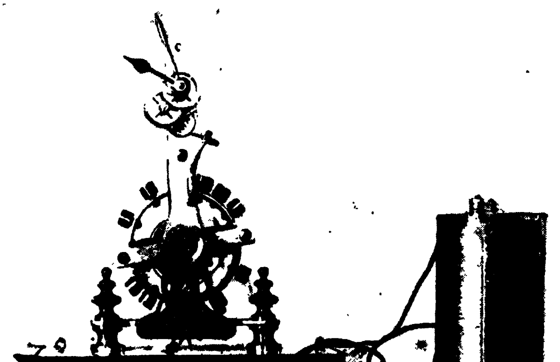
This clock, which was presented to a London municipality, is electrically driven by the pendulum seen in the pillar below. This one pendulum could control the dials of a full service of municipal clocks connected with it by electric wires. It is electrically self-wound, and automatically corrected from Greenwich hourly.

It is impossible to say by whom the weight-clock was invented. Even the date of its invention is unknown. A timepiece composed of an assemblage of wheels actuated by a weight was sent by Saladin of Egypt to the Emperor Frederick II. of Germany, in the year 1232. And having regard to the fact that in the Dark Ages of Europe the Mohammedan races alone carried through the world the torch of science, it is very probable that they were the inventors of the first modern clocks. However this may be, weight-clocks came into use in Europe in the thirteenth century, and they were at first chiefly employed, at cathedrals and abbeys and wealthy monasteries, for indicating the hours of prayer. Few persons could then read a dial, so the hours were struck on bells by mechanical figures, known as Jacks, which excited the amazed admiration of the people. Unfortunately, the devisers of these ingenious marionette exhibitions were far more highly esteemed than the men who merely strove after exactness of time-keeping. But the clock that Peter Lightfoot made for Glastonbury Abbey in 1335 remained in working order until 1835. The iron wheels were then so worn that they had to be replaced, but the old movement which is now controlled by a pendulum, may still be seen in action at South Kensington Museum. It is the earliest modern clock of which we have any authentic details. Most of the old weight-clocks, however, were so defective in working that about the middle of the seventeenth century the principle of the

water-clock was revived and applied in a more scientific manner; and, until quite recently, a water-driven clock was used for driving the equatorial telescope at Greenwich Observatory.

Not until the principle of the pendulum was discovered did the mechanical measurement of time become of scientific importance. But in 1580 a little boy was attending Divine service in the cathedral church at Pisa, and, like many other boys, he took to staring about him instead of saying his prayers. What struck his idle curiosity was a great chandelier that had been lighted and allowed to swing until it came to rest. The boy expected that as the swing of the big lamp grew smaller, it would move more quickly over the shorter space. But it seemed to him that the time it took to swing over decreasing distances was uniform. He wanted some way of measuring the duration of the lessening movement; and, with a flash of genius, he thought of counting his own pulse-beats, and measuring the time the chandelier took to swing first over a large space and then over a small space. To his surprise, he found that all the varying swings of the big lighted lamp were measured by exactly the same number of pulse-beats.

RECEIVING A WIRELESS MESSAGE FOR THE PURPOSE OF KEEPING A WATCH ACCURATE



ELECTRICITY AS THE MOTIVE FORCE OF A CLOCK

This timepiece is shown out of its case for clearness. It runs for a thousand days without attention, and has no pendulum escapement or tick, its hands being driven by power from one dry-cell battery.

When he went home, he tied a weight to a string and set it swinging from a beam. Again he found that no matter whether the arc of the swing was large or small, the time taken in covering the various distances was equal. Thus did Galileo in his boyhood discover that the swing of a pendulum is equal-timed. As a matter of fact, this is true only when the arc of vibration is small.

On the other hand, the weight of a pendulum has no influence upon the time of its vibration. For the effect is produced by gravity, as Galileo went on to show, and the time that bodies take to fall to the ground under the action of this force is independent of the weight. A swinging or falling weight of two pounds is only equivalent to two pound-weights swinging or falling side by side.

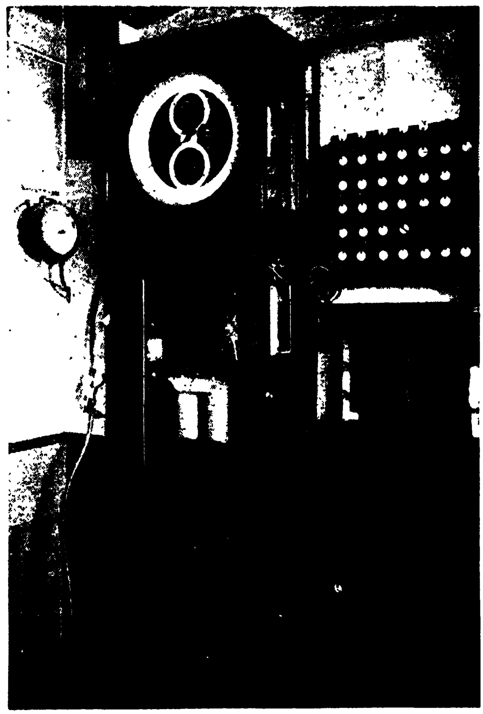
The discovery of the peculiar property of the pendulum gave the makers of weight-clocks the regulating instrument for which they had vainly searched for centuries. A clock consists of two principal parts. There is first a train of toothed wheels, which transmits to a definite point the motive force produced by a weight or spring. But as the motive force would expend itself with wasteful rapidity in setting the train of wheels going at a furious rate, a mechanism is necessary for regulating the expenditure of the motive force with the requisite uniformity and slowness. So the second main part of a clock consists of the pendulum or time-governing device, and the escapement, by

means of which the pendulum controls the speed of going.

It is difficult to describe an escapement mechanism in words, though it is simple in action. But we must at least attempt an explanation of Galileo's contrivance. For, though it was unsuccessful at the time, it contained the germ of the chronometer-escapement and free pendulum which are likely to be the escapement of the future. Galileo made a wheel with a number of pins sticking out, not from its edge, but from its side. Sideways, near the top of the wheel, a ratchet engaged with the pins, and at the same time was connected with the pendulum beneath by a small downward projecting arm. Touching this arm at times was another straight arm, running sideways from the top of the pendulum rod, and moving with it. This pendulum arm extended partly over the side of the wheel, in such a way that it came into contact with one of the pins.

The wheel, of course, went round by the motive force of a weight or spring transmitted through a train of wheels. But as the ratchet engaged with the pins, the entire motion was stopped until the pendulum came swinging back at the end of its beat. The pendulum arm then struck the lower projecting arm of the ratchet, and raised the ratchet from the pin with which it was engaged. So the wheel then went round, and one of its lower pins struck against the arm of the pendulum and thus gave the pendulum its forward stroke. But in making this stroke the pendulum lowered its side-arm. This enabled the projecting arm of the ratchet to drop freely, with the result that the ratchet itself engaged with the next pin on the wheel, and again stopped the movement of the clock till the arm of the pendulum again swung back.

As a matter of fact, this arrangement did not work well, and the use of the pendulum had to wait until Huyghens investigated its mathematics and enunciated the laws governing oscillatory bodies, in 1673. But almost another century clapsed before the escapement mechanism of a watch was converted into a good regulator by the great George Graham, whose famous dead-beat escapement is still used in many a high-class clock today. It was impossible to take a pendulum-clock to sea and suspend it so as to avoid disturbing its motion by the rocking of the ship. The ship's chronometer is a large watch, about six inches in diameter, mounted on gymbals, in a mahogany box.

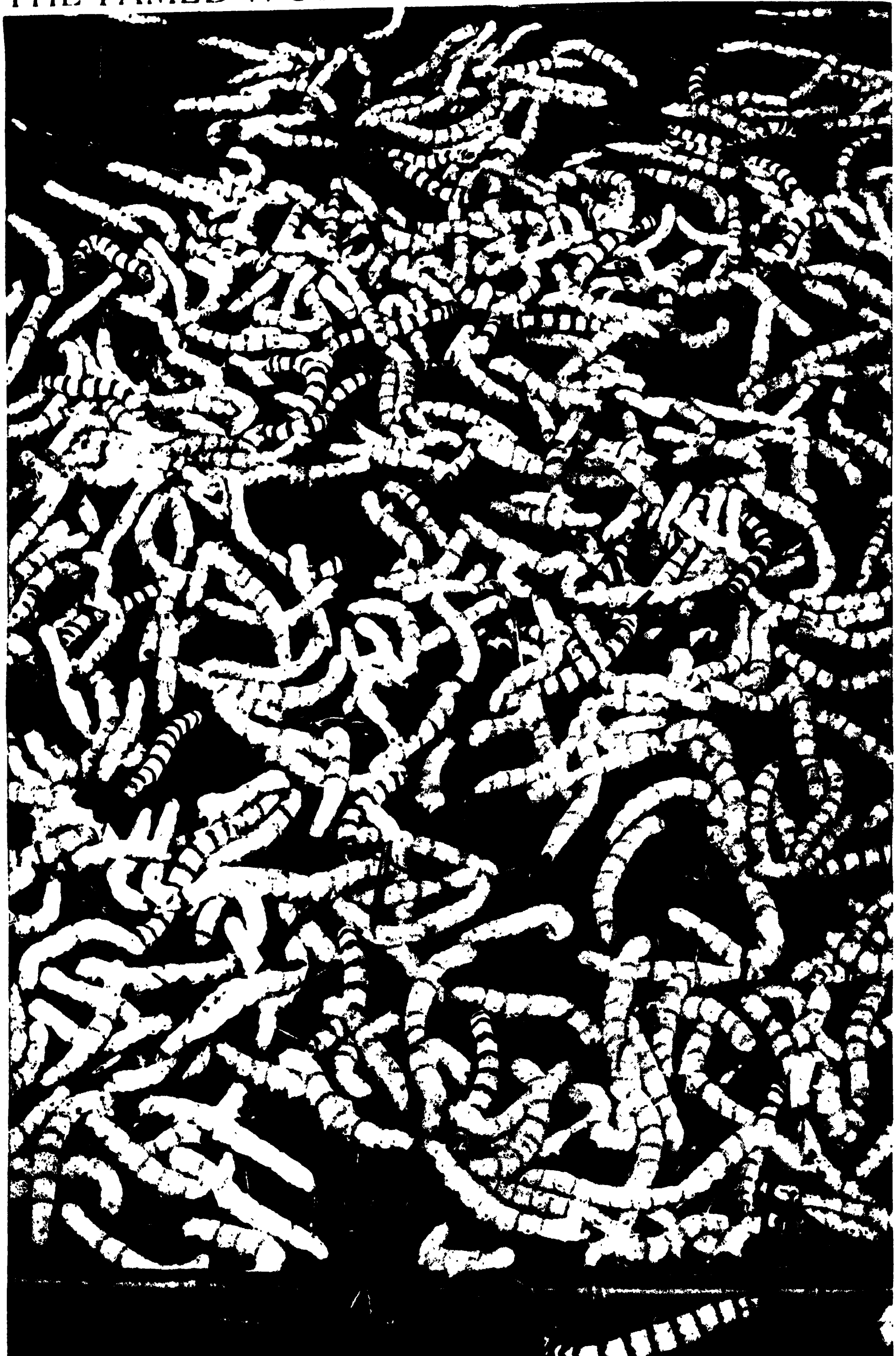


THE CLOCK AT GREENWICH THAT DISTRIBUTES MEAN SOLAR TIME

A modern chronometer escapement consists of a toothed wheel, against which two levers work. A delicate spring at the top of one lever comes at times into contact with a little projection at the bottom of the other lever, so the escapement-wheel is alternately held and released by the interaction of the two levers.

Lastly, we must mention briefly a recent improvement in time-measurement and its distribution by electrical means. One of the greatest difficulties encountered in an endeavour to keep a pendulum swinging in true time is to avoid disturbing the natural period of its vibration by the escapement, particularly at the end of its swing. Mr. F. Hope-Jones, the inventor of the "synchronome" system, in conjunction with Sir Henry Cunynghame, K.C.B., has introduced an escapement which leaves the pendulum free at all times except at the moment when it passes through its middle, or "zero," position. It then releases a gravity lever by means of a chronometer "detent" escapement, and allows it to fall upon the pendulum, giving it an impulse. The gravity lever is then replaced by an electro-magnet; and this action transmits electrical impulses to any number of dials, and advances the hands in perfect synchronism.

THE TAMED WORM THAT CLOTHES THE RICH



A MULTITUDE OF SILKWORMS FEEDING UPON MULBERRY LEAVES AT SHIZUOKA, JAPAN

THE SILK INDUSTRIES

The Amazing Results of the Taming of a Moth Five Thousand Years Ago

THE STRIFE OF SILK-FARMER AND CHEMIST

MAN has tamed many creatures to his uses, but the strangest and most curious of his essays in domestication is that of the silk-moth. For about five thousand years an insignificant and feeble moth, about half an inch in size, has been kept working to make clothes for mankind. It has been robbed of its natural strength, so that it can scarcely fly, and would certainly perish if it returned to its native forests on the Himalayas. It is fed by hand, in light, airy, sheltered rooms; it is protected from disease by troops of human guardians armed with microscopes; and almost from the dawn of civilisation mates have been chosen for it with more care than parents select husbands and wives for their children. No race-horse, no prize milch-cow, has been bred so carefully as the silk-moth has for many thousands of years. It has almost been refined out of existence by extreme domestication, for it has grown so feeble that the condition of its health has had serious effects upon the industrial life of great modern nations. And men of science are still busy trying to find some wild silkworm that will resist disease, and yet produce as fine and abundant a silk as the tamed variety does.

Every year the tiny moth is said to produce more than £70,000,000 worth of silk. But this is probably an under-estimation of its extraordinary powers. For the amount of silk that the Chinese consume themselves is probably very much greater than that which they export. The silk-moths in Europe alone are reckoned to produce annually thread to the value of £30,000,000; and it is probable that the total production of the silk-moths in China and Japan comes to double this amount. Had it not been that towards the middle of the nineteenth century the moth had been so weakened by its strange artificial industrial life that it was almost swept clean out of existence by the attack of a microbe, India would now be a great silk-producing country, and so would France. But at the present time Italy, China, and Japan are unrivalled for the productiveness of their silk-farms. India is still fighting against the silk-moth microbe; France has given up the struggle; while some scientific Austrians at Trent are making a strenuous attempt to convert the poor, weak little moth into one of the principal workers in the villages of Tyrol.

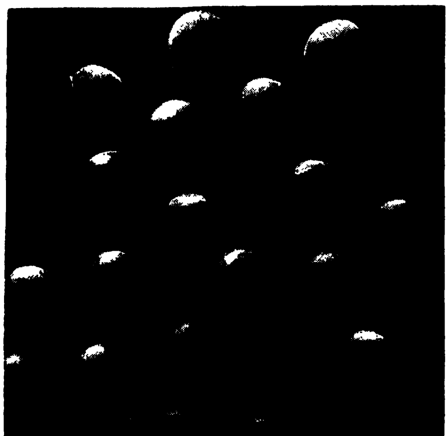
Recently a new silkworm has been discovered in Dalmatia. It feeds on the leaves of oak-trees, and the fibre of its cocoon is said to be more abundant, finer, and whiter than that of the common tamed silk-moth. On the other hand, a wild variety of the domesticated creature has been found on the wooded heights of the Himalayas; so it is thought that these mountains were the original home of the wonderful little thread-maker that the Chinese captured on some mulberry-trees some time before 2640 B.C., and removed for ever from its native woods.

The achievement of the patient and ingenious Chinese was really extraordinary. Very likely they began by collecting the wild cocoons, as some of the jungle races of India still do. The Indian jungle folk never search the trees, for it would be impossible continually to ascend to the tree-tops in the hope of finding there a full-fed caterpillar that had completed its task of weaving a cocoon. The silk-hunters begin by searching the ground for droppings made by the caterpillars, and only when these are found do they climb the trees. If they are fortunate they may find some cocoons still unbroken; but very often the moth has escaped, leaving behind it only the ruins of the little silken house it made

to shelter itself from foes while it was changing from an ugly caterpillar into a winged creature of the air. Perhaps it was after a disappointment of this sort that some Chinaman took to collecting the tiny eggs of the silk-moth, and keeping them until the caterpillars were hatched, and then feeding the caterpillars—or silkworms, as they are usually called—on the leaves of the white mulberry tree. But an infinite amount of care and labour was necessary before the wild moth was developed into the marvellous little domesticated spinner which the Empress Si-Ling-Shih first made famous by breeding it herself in the Imperial Palace. This was in the legendary ages of Chinese history, and legend attributes to the Empress the invention of the loom for weaving silk into the beautifully patterned webs which thousands of years afterwards fetched their weight in gold in the Roman Empire.


THE SILK-MOTH

By this time the silk-moth had become a great source of wealth to the Chinese nation, and there was a general conspiracy to keep the origin of silk a secret from all foreigners. Inquisitive strangers were told that the beautiful material was obtained from the fleeces of sheep, which at certain seasons of the year were sprinkled with water in the sunshine to promote the growth of their exceptionally fine wool; and when this fine wool was combed out it was silk ready for weaving! But about sixteen hundred years ago the Japanese and the Indians managed to discover the secret. The Japanese despatched a secret mission to China, and obtained some silkworms, and induced four Chinese girls to return to Japan and teach the people how to look after the wonderful moths. The Indians conducted their campaign in a more romantic manner. The son of one of their kings wooed and married a Chinese princess, and the bride concealed some of the eggs of the silk-moth in her headdress, and on arriving in her husband's country taught his people the art of sericulture. Two and a half centuries afterwards two Persian monks of the Nestorian school of Christianity travelled from China to Constantinople with some eggs hidden in a hollow cane, which they presented to the Emperor Justinian. From the precious contents of their bamboo tube, brought to Europe about the year 550 A.D., were produced all the generations of silkworms which stocked the Western World, and gave trade, prosperity, and untold wealth to great communities for thirteen hundred years.


THE MOTH'S EGGS AS THEY APPEAR UNDER THE MICROSCOPE

Only a little while ago the Japanese tried to preserve the secret of a new kind of silk for which their country was becoming famous. When the silk-moth plague broke out in Europe and Asia, towards the middle of the nineteenth century, Japan was one of the few countries still unaffected. It was from the sound eggs of her silk-moths that the silk-farms of Italy and Switzerland and France were restocked; and three modern syndicates in these countries now work together and rule the price for yarns and raw material. But the Japanese had also discovered a big wild moth in their own forests—six inches across the wings, and of a bright yellow colour—which wove a large cocoon. The moth fed on oak-leaves, like the wild Tusser silk-moth of the Indian jungles of Central and Southern India, but the thread of the Japanese moth was much finer and more lustrous; it was said, indeed, to be superior to that of the Chinese moth. So no eggs were allowed to be sent out of the country. These, however, have now been obtained,


A SILKWORM SPINNING

but the art with which the Japanese breed and rear the moths still seems to be beyond the reach of the silk-farmers of India.

Until the moth plague broke out, the silk-farms of India promised to outrival those of China itself. For the domesticated Indian moth had developed a strange and valuable quality in its new tropical home. In temperate climes the moth breeds only once a year; in India the silk-farmer had four crops in a twelvemonth. Now, however, he generally loses two entire crops every year, through the same plague that started in France in 1849, and spread throughout the world. It raged unchecked until 1866, when Pasteur discovered the microbe that produced it, and showed how sound eggs and healthy breeds could be obtained by the microscopic examination of the moths. Unfortunately, the small, ignorant Hindoo cultivators will not adopt the scientific method of protecting their stock. So their wonderfully prolific mulberry silk-moths are perishing; and most of the silk now produced in India is obtained from the Tusser oak-feeding wild moth that spins an inferior kind of silk thread that is strongly impregnated with tannin. Very likely, if the Hindoos would only devote to the rearing of their Tusser moth the same art and attention that the Japanese bestow upon their native moth of similar character, the Indian silk industry would quickly revive and be greatly extended. Both Indian and British men of science have tried to arouse the native small-holder from his apathy. But we are inclined to think that the silk production of India will only be raised to its former position when a large number of well-trained British silk-farmers resolve to develop the prolific Indian silk-moth in the same way as the British tea-planters have developed the prolific Assam tea-plant.

THE COCOON BEING SPUN

The eggs of the silk-moth somewhat resemble turnip-seeds. There is about a hundred to a grain's weight. From an ounce of eggs and one ton of mulberry-leaves there are produced 140 pounds of cocoons, yielding about twelve pounds of raw silk. Very often the eggs are kept in cold storage to prevent them from hatching out before the mulberry-trees leaf in spring. This seems to have been done from time immemorial in China, by placing the eggs in jars partly immersed in a stream of cold running water; but in Europe refrigerating machinery is coming into use. Again, when the mulberry-tree is putting forth its tender foliage, it is necessary in many countries to use incubators to hatch the eggs in a quick and regular manner. Artificial incubation has always been a most important process in the rearing of silk-moths; and both Asiatic and European silk-farmers used to tie from one to two ounces of eggs in a small silk or cotton bag, and carry this about their person and next to their skin for three days. At night-time the silken bag, was placed beneath a box under a warm bolster in the bed of the breeder. On the evening of the third day the bag was emptied into a wooden tray, on which some shredded mulberry-leaves were scattered, and again placed beneath the warmed bolster, and in the morning the tiny little caterpillars began to

THE COCOON BEFORE AND AFTER THE ROUGH SILK IS REMOVED

A COCOON CUT OPEN, SHOWING THE CHRYSALIS WITHIN

break out of their shells. Then, on the top of the hatching-box, a sheet of paper, full of holes made by a large pin, was placed, and lightly covered with shredded mulberry-leaves. The tiny caterpillars crawled through the holes, and fixed upon the leaves, and when these were almost black with the creatures they were gently raised and placed upon feeding-trays. This method is still followed by Oriental nations, but in modern silk-farms much trouble and loss in broken eggs are saved by using little artificial incubators. But it says much for the ingenuity of the Chinese race that they managed, four or five thousand years ago, perhaps, to devise both a simple cold-storage treatment and a kind of artificial incubation.

The domestication of the silk-moth involved problems of rearing far more difficult than the breeding of cattle and horses and sheep; and the manner in which the problems were surmounted is evidence of the curious inventiveness of the Chinese mind. The brilliant talent which the Japanese are now displaying in the study of the germs of disease is, we think, partly due to the fact that the Japanese race has for nearly two thousand years been trained in Chinese ways and Chinese technique. And when the Chinese themselves begin to co-operate in a large way in the progress of modern science, their extraordinary patience and their extraordinary regard for little but important things will probably make them admirable in the most exquisite and laborious methods of scientific research. It is only since European men of science began to control the gnat in order to stamp out malaria and other diseases that our race has attempted a task of such minute delicacy as the Chinese carried out when they domesticated the apparently insignificant silk-moth.

PICKING MULBERRY-LEAVES IN A GROVE

It is also to the Chinese that we owe the cultivation of the white mulberry-tree, on which the silk industry largely depends. The ordinary mulberry-tree that is grown for fruit is not so valuable in silk-farming as the one that produces small and useless berries. The trees must be cultivated only for their leaves, and they must be fed with plenty of rich manure in order to develop their foliage as early as possible. Young trees, three or four years old, are best, and about five hundred of them will grow well on an acre of ground. Each tree should yield not less than twenty pounds of leaves in a season. This is enough to feed a hundred silkworms, which will produce about a pound of cocoons; from these about two ounces of the best silk may be reeled, and the remainders of the silk-cases can be combed out like cotton and made into spun silk, which has about half the value of the natural silk thread.

At the beginning, the task of feeding the tiny caterpillars is easy, provided they have been hatched out in largish quantities at regular intervals. Each tray of silkworms, on the open shelves of the silk-farm, must be of the same age, so that they will all go through their processes of growth and their work of silk-spinning at the same time. When this has been arranged by means of cold storage and artificial incubation, the worms can be handled in a wholesale manner, without having to be touched and picked up singly by the farmer. Practically all that is needed is a warm and yet well-ventilated room with open shelves, on which the food can be placed without disturbing the little creatures. At first the worms will occupy a very small space on

the shelf, but as they grow larger they must be induced to scatter by spreading their food more widely. Young, tender leaves must at first be shredded for them, and served to them at morning, noon, and night. And as disease is produced if the leaves are damp, they must not be gathered with the dew upon them, or after a fall of rain. So it is best to keep in hand a couple of days' supply of food, to tide over the exigencies of bad weather in the mulberry plantation.

Four times in the course of their brief life the caterpillars fast for some days. In these periods of apparent rest they slough off their skins, and in about a minute they appear in a new and larger coat. In this way they grow at last to the size of about three inches. The time they take in passing through their four moultings depends upon the warmth of the season and the climate. In England each period is about five days long, excepting the first, which is about seven, and the last, which is about ten. It is after the last moult that the labour of the silk-farmer grows really hard. The caterpillars must be fed late at night and early in the morning and several times during the day, and great attention must be given to the quality as well as the abundance of their food. For they are now amassing the material which they intend to spin into silk. Air and light must be freely admitted into the room, and the great litter that the worms now make must frequently be cleared away, and all their surroundings kept neat and clean.

THE MULBERRY-TREE THAT WAS INTRODUCED INTO EUROPE FROM THE FAR EAST TO FURNISH FOOD FOR THE SILKWORMS

Having arrived at their utmost growth of two and a half to three inches in length, the caterpillars will cease to eat, and crawl

about the shelf, searching with outstretched heads for a nook in which to spin. The spinning-places are provided by the farmer in a number of ways. Often a screen of interlaced twigs is erected around the shelves, the space between the twigs being so arranged that the little spinner need not waste much of its silk in hanging its cocoon among the branches. Little tubes of hollow bamboo or paper are also furnished by some silk-farmers, to save the spinner the trouble of making a web among the twigs. In China large mats are placed by the shelves, the whole surface of the mats being covered with curled strips of material that form spiral rounds, about an inch apart. Between these rounds the worms spin, without wasting any of their floss in making a kind of airy scaffolding to support their silken house.

PLACING EGG PACKAGES INTO AN INCUBATOR

On finding a fit place, the silkworm begins its work by spinning some thin and irregular threads to uphold the future structure. Upon these it forms on the first day a kind of oval of a loose texture, which is called the floss silk; and within this oval, in the next three days, it fashions the firm and valuable ball of silk. It always remains on the inside of the ball, and there, resting on its hind part, it fastens and directs the thread with its mouth and forelegs. The thread is not fixed round and round on the inside of the ball, but is spun backwards and forwards in a wavy figure; and this is why a ball, in reeling off its silk, will not often turn round once while ten or twelve yards of thread are being drawn out.

Twenty-four hours after beginning to spin, the little worker is hidden from view; and in from three to five days it finishes its cocoon, in shape and size somewhat like a pigeon's egg. By this time the industrious caterpillar has lost half its weight and shrunk to half its size. Housed in an egg-shaped lodge, it moults for the fifth time and changes into a chrysalis, shaped somewhat like a kidney bean, but pointed at one end and having a brown, smooth skin composed in rings, with its cast coat lying inside the ball with it. Left to itself, the chrysalis moults for the sixth time, and softens with a liquor from its mouth one end of the cocoon, and then loosens the silk that it has wetted, and emerges as a small, white, feeble moth. It is so broken to the service of man that, if it is a female, it has scarcely the strength to flutter its wings. It is fairly easy to select about an equal number of males and females for breeding purposes, as their cocoons are differently shaped. The creatures live but for a few hours, and are so feeble that they have to be mated by the silk-farmer. Each female moth lays from three to four hundred eggs, and then dies shortly after its partner. The eggs are collected and examined, and then put in cold storage for the spring.

At the Bacological Institute of Trent, three hundred women are employed night and day in catching the moths in cells of gauze or waxed paper as they emerge from the cocoons. The cells are hung from the ceiling, and in them the moths lay their eggs and die. About three million cells are used, and from them are obtained twenty-five thousand ounces of eggs. Some women open the cells, some remove the dead moth and crush it for microscopic examination, which is conducted by forty women armed with microscopes. If no sign of disease is found, the eggs are kept in the Institue through the winter, and in April they are taken out of the cold-storage room and distributed to customers in the villages of Tyrol.

This is the way in which all the silkworm seed of a country should be obtained. A

central breeding-station, with its scientific appliances, is able to keep the national stock of silk-moths free from microbe attack. Moreover, by conducting its operations on a large scale, it can sell the seed at a very low price. The Trent Institute, for instance, sells its seed at one-third of the ordinary cost. It buys selected cocoons from the breeders, brings a few of them rapidly to maturity in incubators, and thus

MAKING BEDS FOR THE YOUNG CATERPILLARS ON WHICH THEY GROW AND ARE FED

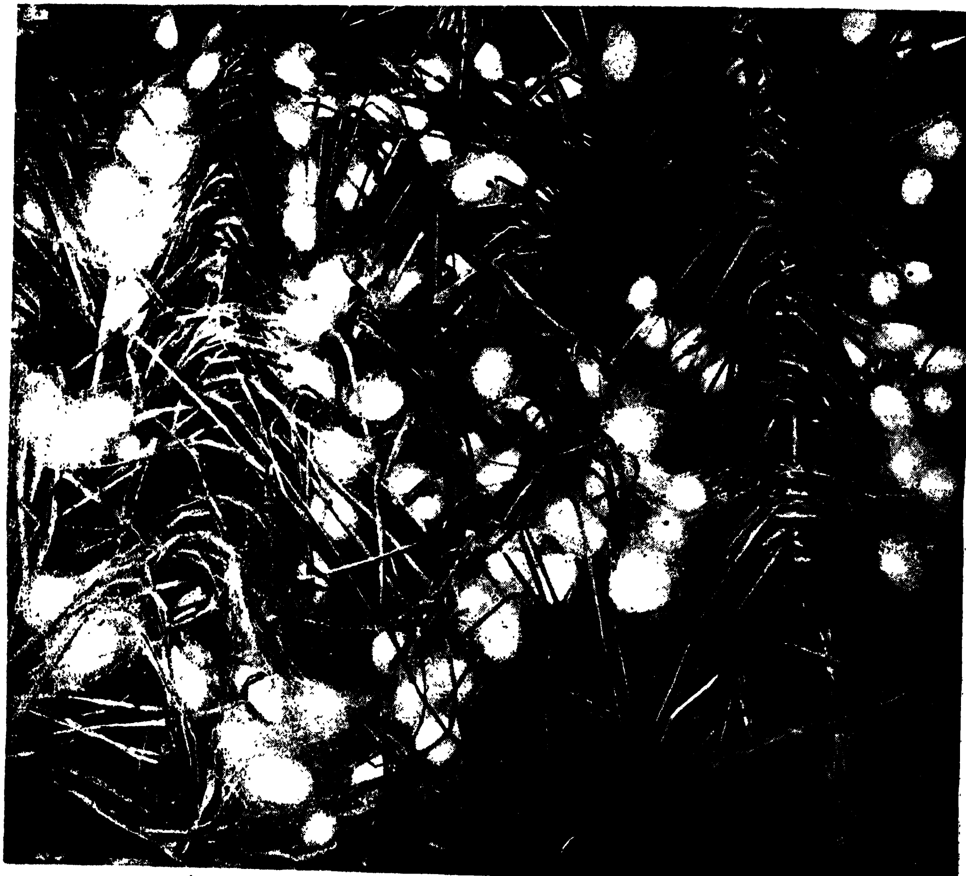
tests the quality; and if this is satisfactory the bulk of the cocoons is placed in boxes, and the chrysalises are there allowed to develop in a normal manner. By this modern method of breeding, the Tyrolese are quickly winning their way to a position of considerable importance in the European silk market, using French science in building up an industry that now seems lost in France.

A well-organised body of British silk-farmers could by the same method rapidly raise India to her old position as a silk-producer. For they would have one of the cheapest supplies of labour in the world, and a climate in which four crops of silk could be obtained every year. The furnishing of a silk-farm is extremely simple and inexpensive, particularly in a hot climate where little or no artificial heat is ever needed. Some open sheds, in which are long, light frames for holding lightly woven mats of reed on which the caterpillars live, and some brushwood or Chinese mats for the spinning of the cocoons, are practically all that is required, in addition to the mulberry plantations surrounding the sheds. Incubating stoves are scarcely required in so warm a climate,

though they might be useful in regulating the hatchings.

Nowadays, few European silk-farmers reel their cocoons. These are usually collected and dealt with in factories. At least, this is done in Europe at the present day, and it is becoming somewhat of a general practice in China and Japan. Home-reeled silk, taken from the live cocoon, is more lustrous than factory-reeled thread, and this is why both the raw silk and the woven fabrics of China are more brilliant than the products of Europe. On the other hand, the system of factory reeling results in a more even and stronger thread. And as strength of thread is a vital necessity in weaving on power-looms, the brilliant lustre preserved by the old-fashioned method of reeling is now generally sacrificed.

By whatever method the cocoon is reeled, the task is quite easy. The silk ball is thrown into a tank of warm water to soften the silk-gum and set free the fibre. The loose outer case of floss silk is then removed, and the end of the thread forming the true cocoon is readily found. This thread is several hundreds of yards long, and it is this extraordinary length of unbroken fibre which distinguishes silk from cotton, linen, wool, and other weaving materials. There is no need to card it and twist it; it needs only to be unreeled. Yet it is so fine that thirteen hundred yards weigh only the seventeenth part of an ounce. This extreme tenuity, however, is of no practical use. So the reeler usually takes six cocoons from the tank, and passes their threads over a rod, and through the eyelet holes of the machine, through which they run in a compound thread on to a revolving wheel.

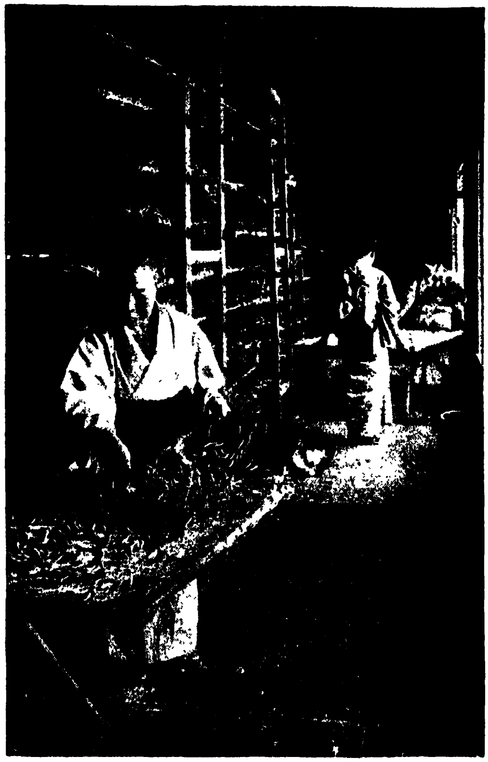


THE SILKWORM'S WORK COMPLETED—COCOONS FROM WHICH RAW SILK IS OBTAINED

When reeled into skeins the material consists of raw silk. It is composed of two substances secreted by the silkworm—fibroin and serecin. Fibroin is a horny kind

SILKWORMS AS WORKERS IN A FACTORY

FEEDING SILKWORMS WITH MULBERRY LEAVES



MAKING BEDS FOR SILKWORMS TO SPIN UPON

PICKING OUT THE FINISHED COCOONS

WEIGHING THE SELECTED COCOONS

of substance that forms the core of the thread. It cannot be dissolved in water, even at boiling heat. The serecin can be so dissolved, for it is a kind of gum deposited on the surface of the thread. As produced by the silkworm, silk consists of two fine strands of fibroin, slightly twisted together and coated with the gum. The fibre is about the three-thousandth part of an inch in thickness, and of remarkable strength. A twisted thread of it, finer than the finest human hair, will stretch half a foot to the yard, and support a weight of about a pound. No other fabric material is so strong. Pure silk is both more beautiful and more durable than any vegetable fibre; and if it were not now so terribly adulterated it would often prove more economical in use than all fabrics of cheaper stuff.

The first step in the manufacture of silk is known as "throwing." The skeins are soaked for some hours in warm, soapy water, and then dried and stretched on a light skeleton reel called a "swift." Having found the end of the thread, the woman winder passes it through a guide wire and lightly attaches it to a revolving bobbin. As the bobbin revolves it draws the thread from the wheel, with so gentle a motion that if the threads stick through any reason the machinery stops. Thus the breaking of the thread is avoided, and hundreds of yards of continuous fibre are neatly wound on each bobbin. The thread is afterwards rewound over a double knife that cleans the silk of all unevennesses and hairy filaments.

THE STOVE FOR SUFFOCATING THE CHRYSALIDS

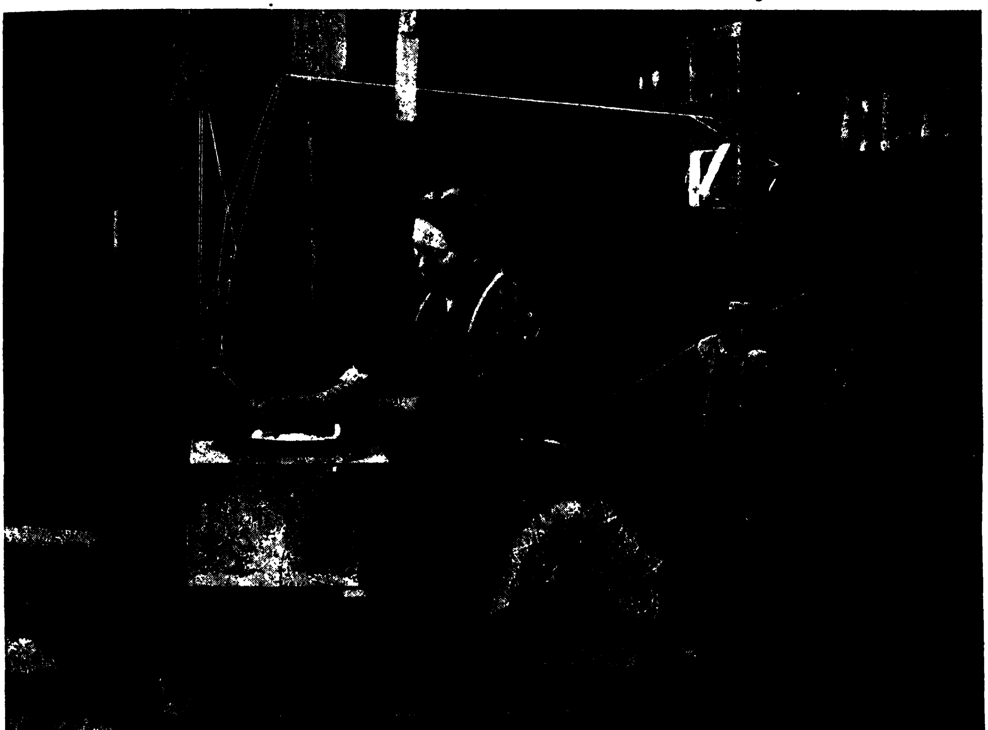
The next process is sometimes called spinning, but the proper term is throwing. For silk does not need to be spun, except when it consists of the little broken fibres obtained from the outer covering of the cocoon. It already consists of a long, continuous thread, and as soon as it is cleaned it can be woven into pongees. But to make stronger fabrics the single silk is twisted into a little compound thread on a throwing-frame. The action of the frame depends on two sets of bobbins that revolve at different speeds, and, by the way in which their revolutions are adjusted to each other, more or less amount of twist is given to the thread thrown. The two chief varieties of thrown silk are organzine and tram. To the organzine a great deal of twist is given, to make it hard and strong.

It is used for warps, which are the long, lengthways threads of a web that are tightly stretched in the loom before weaving begins. They bear the strain and the friction of weaving, and thus need to have great strength and evenness. Tram is less twisted than organzine, and therefore more soft and more flossy. It is used for the weft or filling, or the crosswise thread that knits the warp together into a web of fabric. There is little strain on the weft, but it must be soft and bulky, so that its successive threads may lie close together and fill up the interstices of the silk.

At the beginning of the eighteenth century the art of throwing silk into organzine and tram was the chief secret of the Italian silk manufacturers. But a Derbyshire man, Mr. John Lombe, went to Piedmont and obtained a position as an ordinary labourer in a throwing-mill. There he worked for some years, until he learnt the secret of the machinery and the method of treating the thread. He was discovered taking drawings, and had great difficulty in getting away alive. But he did escape, and, returning to his native country, he built on the River Derwent a huge throwing-machine with more than ninety-seven thousand movements and twenty-six thousand five hundred

wheels, that worked by water-power. The building was five storeys in height and an eighth of a mile in length. But before the adventurous builder was able to profit fully by his adventurous labours, he was poisoned by an Italian woman who followed him to England. It was never ascertained whether her motive was public or private vengeance. The business was carried on by a cousin of the founder, who made a great fortune. And during the eighteenth century other English silk-mills were founded at Macclesfield, Leek, Southport, Congleton, and St. Albans and other places, most of which are still working. We have to rely on other countries for the supply of raw silk, but our manipulation of the fibre is unrivalled by either the French or the Italians. The Germans are successful with the cheaper kinds of silk fabrics, but these do not last.

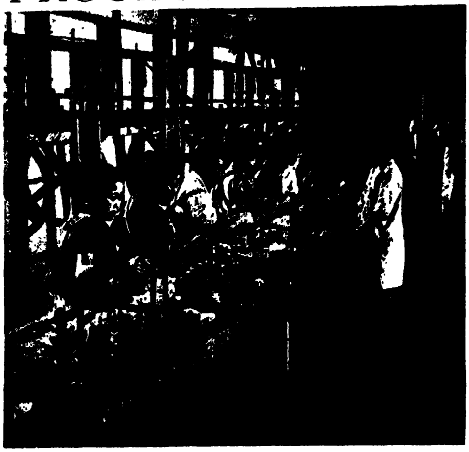
In making cheap silk, the thread is woven as soon as it is thrown—that is to say, the silk is not first boiled and dyed. Good silk goods, however, are woven from yarn-dyed thread. The skeins of silk are first boiled, in order to extract the gum and the colour. Before being boiled, silk is harsh and wiry, resembling somewhat fine horsehair. It also differs in colour, according to the place of its origin. Italian silk is yellow; Chinese and Japanese wild silk is of a light fawn colour; Indian wild silk is dark fawn in tint; while the best Chinese silk is nearly white. But the boiling extracts the colour as well as the gum, and leaves the thread of fibroin soft, white, and brilliant. The weight of the material is also considerably lessened, sixteen ounces being reduced to twelve after being boiled for two hours in soapy water and then rinsed thoroughly to get rid of the gum and soap. Copper tanks, known as barcs, are used in dyeing. They are about two feet wide and two feet deep, and vary in length according to the quantities of silk to be dyed. The skeins of silk are placed on sticks that rest on the edges of the barc, letting about three parts of the skein hang in the bath of liquid dye. By turning the skein on the stick at regular intervals the dyer gets all the material equally coloured.



A JAPANESE WOMAN REELING THE SILK OFF A COCOON

The liquid in the barc is formed of the water in which the silk has been boiled, and with it is mixed the dye-stuff, which is either a natural product or an alizarine synthetic chemical, the ordinary aniline dyes being unworthy of being applied to

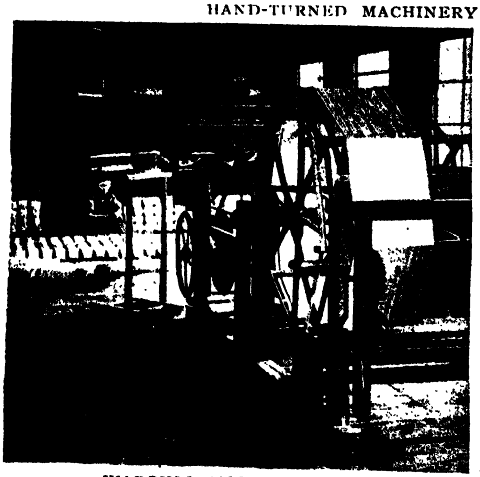
PROCESSES OF SILK MANUFACTURE



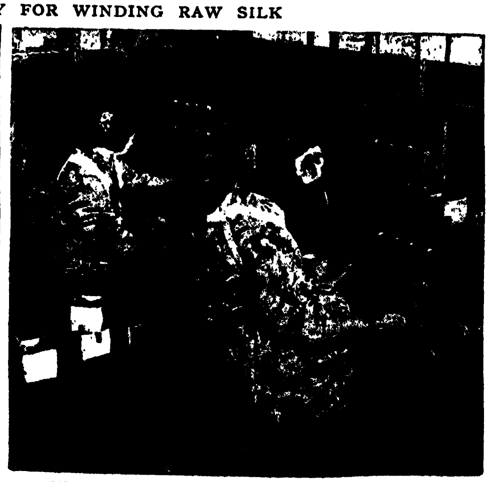
REELING SILK FROM COCOONS IN HOT WATER

WINDING RAW SILK INTO SKEINS

HAND-TURNED MACHINERY FOR WINDING RAW SILK



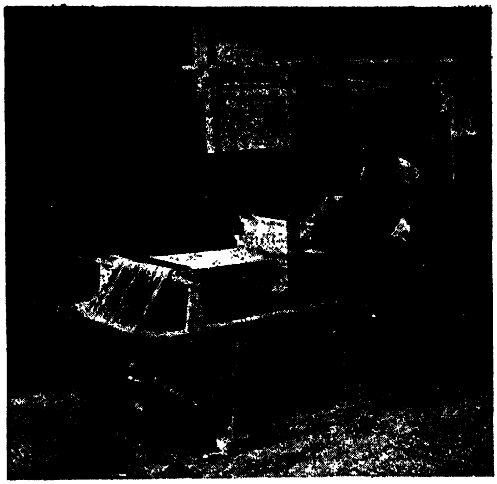
WARPING SILK THREADS



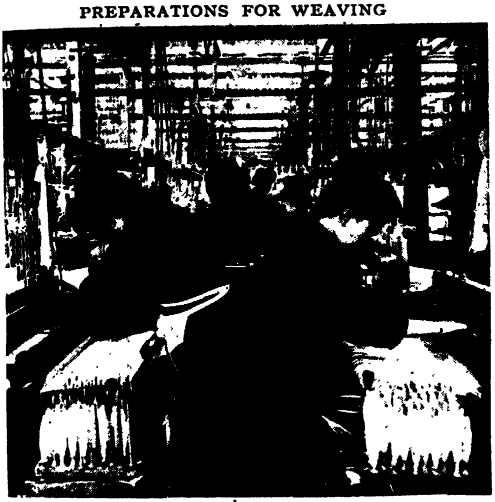
WINDING SILK ON SHUTTLE BOBBINS

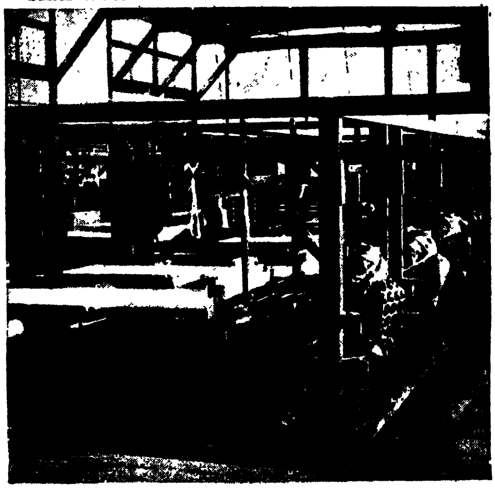
IN A LAND OF SILKWORMS & CHEAP LABOUR

PREPARATIONS FOR WEAVING



SILK-WEAVING AS A DOMESTIC INDUSTRY





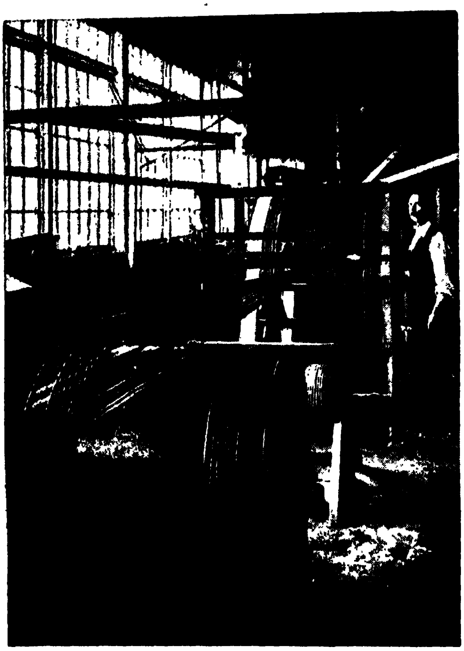
GIRLS ATTENDING TO THE WEAVING OF THE SILKEN FABRIC

BOILING GUM OUT OF THE SILK

DYEING THE FINISHED PIECES

good silk. Before being placed in the dye, the skeins are immersed in a solution of certain chemical salts, which prepares them for the action of the dyes. This process is called mordanting; and sometimes, when two skeins, that have been differently mordanted, are afterwards placed in the same dye they acquire entirely different colours. While the silk lies in the dye, steam is turned on, and the liquid is gradually brought to boiling-point. The dyer tests the colouring process by taking a skein off one of the sticks and drying a few of its threads. If the tint is right, the silk is rinsed very thoroughly. Then each skein is hung on a wall-peg and twisted by means of a stick, with all the force that the dyer can use. This is called scrouping; and though it may seem a severe process for so delicate a thread as silk, yet the fibre is so strong that the harsh wringing only enhances its glossy lustre. After the dyer has squeezed the silk nearly dry, the skeins are finished in a drying-room, and they are then rewound on bobbins ready for the weaver.

Unfortunately, both yarn and piece-silk are greatly adulterated at the present time. The boiling removes much of the natural gum, and lessens the weight by about one quarter, and, to make up for this, unscrupulous dyers and manufacturers resort to "loading." Silk has a great affinity for water, and it can absorb one-third of its own weight without feeling wet to the touch. But the dyers soon found that it would absorb other things besides water, and especially solutions of salts of tin and iron. Indeed, silk will take up so much of these metals with the dye that twelve ounces of boiled fibre can be increased in weight to eighty ounces, and still look like very bright silk. Most people like silk to look very bright and shiny. They are so accustomed to the adulterated material that they cannot recognise a piece of pure silk when they see it. As a matter of fact, pure silk has a subdued, pearly lustre, whether it is merely boiled off and freed from the gum, or carefully dyed with pure colour.



"BEAMING" OR "TURNING ON"—SILK COMING FROM THE REEL AND SPREADING OUT ON TO THE WARP ROLL

Very brilliant silk owes its brilliancy to the great amount of metal or vegetable matter with which it has been adulterated. Many silks in the market are now heavily loaded, and it is almost impossible to purchase pure silk goods that will stand the test of time and wear. The breaking-strength of a given unit of dry China raw silk is, say, 53. But some French silk, dyed blue-black and very heavily loaded, has a breaking-strength, for the same given

SILK'S FINAL TRANSFORMATION SCENE

MAKING PLAIN SILK UPON A NARROW HANDLOOM

PATTERNED VELVET FABRIC AS IT LEAVES THE LOOM

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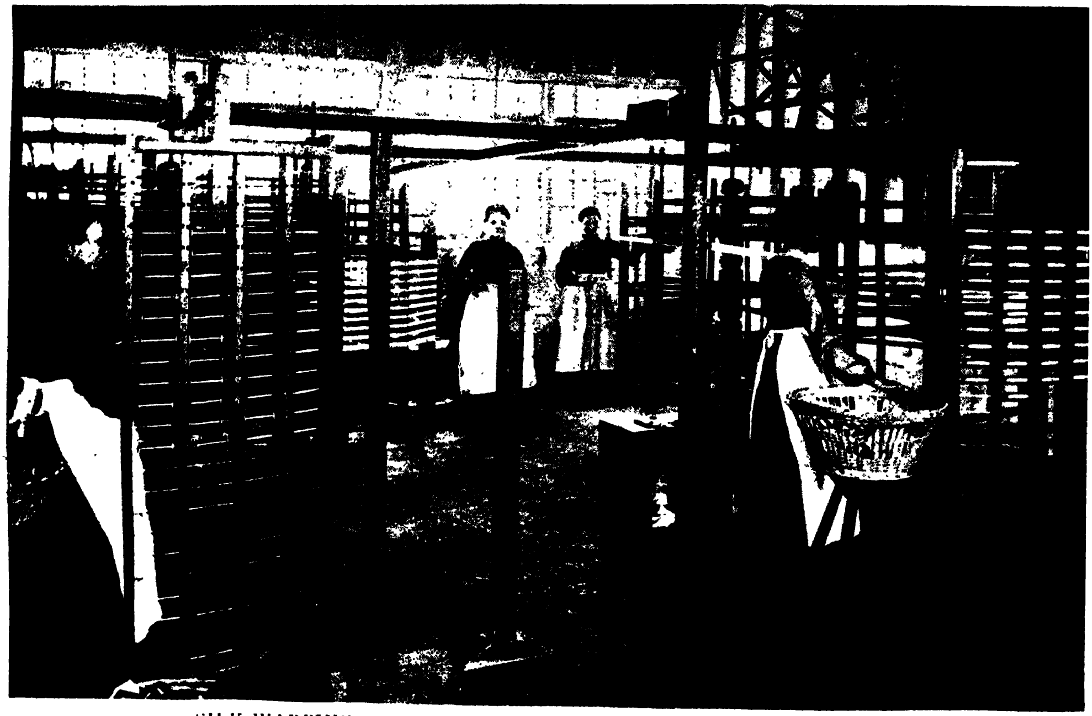
unit, of $2\frac{1}{8}$. This, we will admit, is the worst case known to us; and an ordinary loaded silk may often be purchased with a breaking-strength of 10 or 12. But this is only about one-fifth of the original strength of the best natural silk.

Now, a silk can be made from wood-pulp with a strength of $21\frac{1}{2}$ when dry, and a little under $5\frac{1}{2}$ when wet. Thus, at its weakest, it is superior to a very heavily loaded natural silk in a wet condition. This is the reason of the sudden and extraordinary development of the new processes of making artificial silk. Unless the dyers and manufacturers of fabrics woven from natural silk put a quick end to the shocking adulteration which has been largely practised, they will find in the immediate future that a group of English chemists has almost destroyed their industry. As we have seen, artificial silk becomes very weak when it is wetted. The same thing happens to a less extent with boiled natural silk. It has a breaking-strength of, say, $25\frac{1}{2}$ when dry, and only of about $16\frac{1}{2}$ when wet. At present the best kind of artificial silk is almost as strong in its dry state as the best boiled-off natural silk, but when it is wet it is about $2\frac{1}{2}$ times weaker than wet natural silk. This disadvantage has not interfered with the larg and still increasing use of artificial silk and we are inclined to think that, if th loading of natural silk continues, th marvellous product of the silk-moth wi be generally excelled by the creation o some English chemists. For a process o making artificial silk that will stand bein wetted has already been devised, and it onl needs a cheapening of some of the chemica employed in order to make the new inven tion of tremendous commercial importance

At present there are three processes o making artificial silk from wood-pulp o any other cheap source of cellulose. In th first process, covered with French and German patents, nitric acid is used. To prevent the nitrated thread from burning or exploding, like gun-cotton, the nitrate is afterwards removed, forming a product which is now an ordinary staple textile. In another German invention the wood-pulp is treated with a mixture of copper and ammonia. But the most famous and the strongest of artificial silk is the recent English invention, Viscose, to which reference has already been made in POPULAR SCIENCE.



SILK-WARPING ON A HAND-MILL IN AN ENGLISH FACTORY

A cubic metre of wood worth 3s. can be transformed into artificial silk worth £7 10s.

MANUFACTURING SILK FROM SILK-WASTE

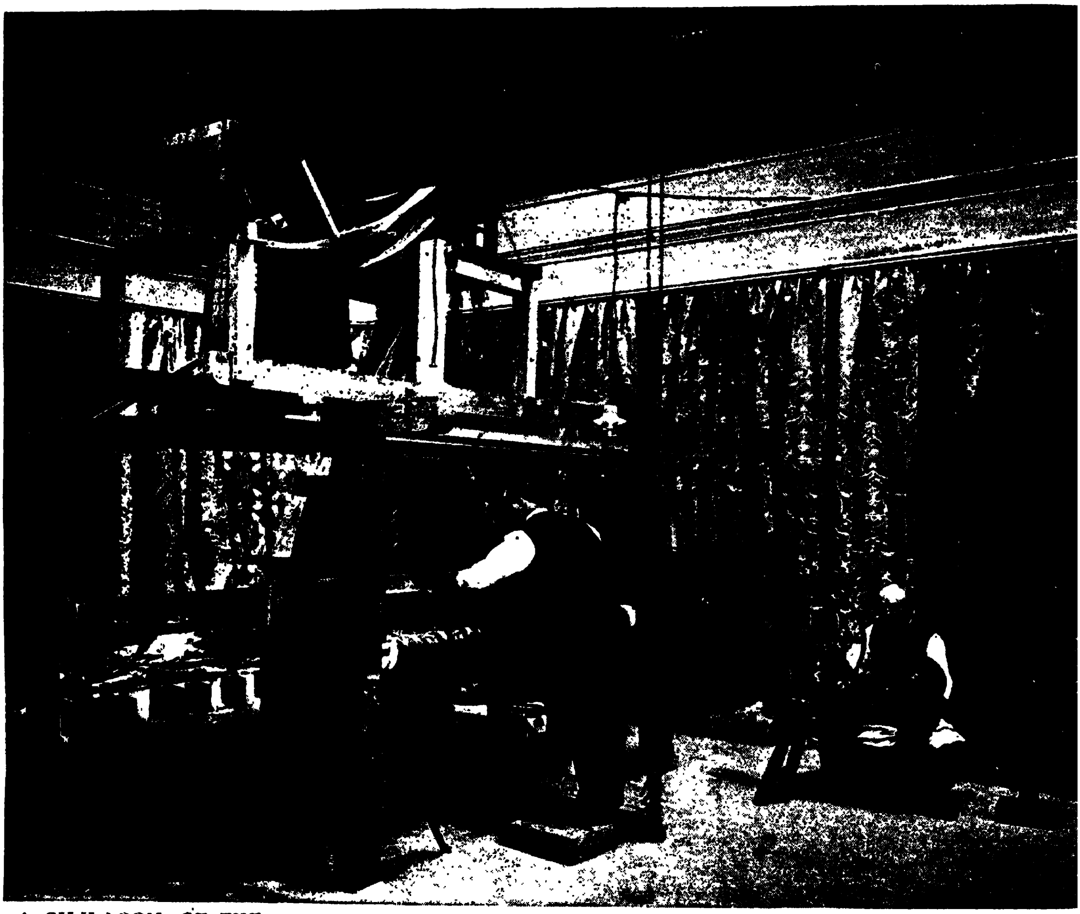
THE RAW MATERIAL AS IT ARRIVES AT THE SILK-WASTE FACTORY

THE PROCESS OF SPREADING THE SILK-WASTE AFTER IT HAS BEEN CLEANED AND DRESSED

DRAWING THE SLIVERS, PREPARATORY TO THE SPINNING OF SILK YARN

The wood-pulp is first treated with a mixture of caustic soda and water, and when drained it looks like bread-crumbs. It is then put in a churn, and on it is poured a quantity of bisulphide. It turns a yellow colour in the churn, and grows slightly warm, and water is then stirred into it and it is passed through a very fine filter. There are two ways of forming the liquid into a thread. In one it is sent through a number of fine glass tubes, and the separate threads are united in passing through a glass loop. In the second method the Viscose is sent through a nozzle of platinum, perforated with fourteen to eighteen holes. Each hole contributes a thread, and all these threads are drawn forward through a tank of liquid chemicals, which purifies the Viscose. In the form of a compound thread, the strands ascend a glass roller and fall through a funnel into a spinning-box. By its motion the box draws the thread forward, and twists it, and lays it down in the shape of a hollow cocoon. In this form the artificial silk is taken at intervals from the spinning box, and rewound into skeins, and further manipulated for the purification of the cellulose.

Artificial silk thus prepared is much stronger than that obtained by the other processes, yet it is still inferior to unadulterated natural silk in its resistance to rain and moisture. But it has recently been discovered that, by treating wood-pulp with formalin, a chemical silk can be formed that resembles good cotton in its resistance to the weakening effect of water. So it is likely that an artificial silk, about as good as boiled-off unadulterated natural silk, will be put on the market. It will be cheap, brilliant, and durable; and dyers and manufacturers will have reason to regret having, by adulteration, buried the fair fame of the industrious little silk-moth.



A SILK-LOOM OF THE TYPE USED IN THE HOME INDUSTRY, AS EXHIBITED IN THE SILK EXHIBITION DURING THE SUMMER OF 1912

THE MEANING OF VALUE

The Remarkable and All-Important Interplay* of Supply and Demand

MONOPOLY'S RELATION TO SUPPLY

We have already seen that the division of labour was the origin of trade. It became that as soon as the division of labour passed beyond the limits of the family—as soon as the bread-winner of one family turned his attention chiefly, let us say, to making weapons, while the head of another specialised in moccasins, or belts, or ornaments. We have now to observe that from the division of labour sprang value in its economic significance. That significance must be carefully and precisely understood.

In its economic sense value does not mean usefulness; indeed, things may even be useless for any good purpose and yet have economic "value." To the economist, a thing possessing value must have *value in exchange*. A commodity which cannot command other commodities in exchange has no economic value. Thus the water of the ocean, which is so valuable in the ordinary sense that without it the world could not exist, and navigation could not be conducted, has no economic value. Similarly, the atmosphere, without which all organisms would perish, although invaluable in the ordinary sense, has no economic or exchange value.

Using value, then, in its economic sense, we see that it is a relative term. One commodity is exchangeable for varying quantities of other commodities at different times. At any one time it will exchange for more of this or less of that. A very large quantity of things easily secured will exchange for a very small quantity of things difficult to obtain. Broadly speaking, some kinds of commodities are in general produced easily, and large quantities of them, therefore, are needed if we desire to exchange them for other things which are difficult to procure or to manufacture. At different times the ratios vary considerably, however; in one year a much larger quantity of corn may be required to purchase a small piece of iron than in another year.

The conception of value as a *relative* term cannot be too clearly understood. At any given moment the value of one thing may be falling relatively to one commodity and rising relatively to another. Let us consider two consecutive years, 1911 and 1912. Let us suppose that in 1912 as compared with 1911 the supply of rubber is increasing more rapidly than the supply of corn, while the supply of iron is decreasing. In such hypothetical conditions, corn in 1912 is rising in value as compared with rubber, but falling in value as compared with iron. We should have, in 1912, to give less corn than in 1911 to get a given quantity of rubber, and more corn than in 1911 in order to get a given quantity of iron. Exchange value is thus purely a *relative* thing. Thus, in the case quoted, who can say whether the value of the corn has risen or fallen? It has actually done both, according to whether we consider it in relation to rubber or in relation to iron.

What, then, do people mean when they talk about values falling at a certain time or rising at a certain time? The answer is that they do not quite know what they mean, and that they are suffering from a confusion of thought. It is important to see how this confusion of thought arises. As we saw at the opening of this study of Commerce (Chapter 1) the early processes of bartering corn for meat, or meat for metal, gave way to the invention of money, and barter became exchange as we know it to-day—*i.e.*, an exchange of commodity A into money in order to effect a further exchange of the money into commodity B. Money, which we shall have occasion to study in more detail, is merely a certain

commodity used and recognised as a standard of value, and expressing the exchange value of all commodities in the terms of one commodity. Barter becomes simplified into buying and selling for money.

Consequently, when all values become an expression of what we can exchange everything for in terms of money, we get the phenomenon of *Price*, which is simply the *ratio of the article we select as money to all other commodities at any given moment.* Now we see why people talk loosely of a fall in "values," when what they mean is a fall in "prices"—*i.e.*, an increased plentifulness of things in general in relation to the accepted standard of value.

If we have clear perception of value as a relative term, and of price simply as an expression of the relation of commodities in general to a particular commodity—money—at any particular moment, we are helped to think clearly upon many common phenomena which otherwise escape our comprehension. For one thing, it helps us to see that a rise in prices does not make people richer, or a fall in prices make them poorer, as is so often loosely thought. Properly understood, this would save us from imagining that by artificially holding up the prices of commodities we do good to industry or commerce. The price-raising syndicates and rings which are becoming so common at the beginning of the twentieth century overlook the importance of the simple considerations we have just stated.

For example, there is, let us say, an ironmonger and a grocer in the same town. The ironmonger thinks that he gains by charging an artificially maintained price for a piece of ironware bought from him by the grocer. The grocer equally thinks that he is gaining something by charging an artificially maintained price for a bottle of lime-juice bought from him by the ironmonger. It will be perceived, however, that such artificial additions cancel each other, and that what has really taken place is that the ironmonger and the grocer have bartered a bit of ironware for a bottle of lime-juice. Whether they label the transaction a shilling, or two shillings, or five shillings, really matters nothing, and neither has gained by the artificially enhanced price.

A general rise or a general fall of prices simply means an alteration in the value of money, and does not matter except as it affects contracts for receiving and paying fixed sums of money. Obviously, it matters a good deal to an annuitant, who, being in receipt of a fixed sum per annum, finds in a time of rising prices that he gets less for his fixed money income. As to future transactions, however, it makes no difference. In this connection it should be observed that it is of much importance to earners of wages and fixed salaries that they should obtain a rise in monetary income in times of rising prices. If they do not, their share of the national dividend falls, although the national dividend may be increasing not merely as expressed in current prices, but as expressed in actual quantities.

This important point, which affects all recipients of fixed incomes, salaries, or wages, but is especially severe in its incidence upon those with tiny incomes, the greater part of which has to be spent upon the bare necessaries of existence, has, unfortunately, been illustrated in the experience of the last fifteen years. Since 1895 as we have already had occasion to notice in these pages, there has been a considerable rise in prices. The Board of Trade have traced the dimensions of this rise as it affects both wholesale prices and the retail prices of food in London. If we express the prices of 1900 by the figure 100, then the prices of the years 1895-1911 are as follows.

BOARD OF TRADE ESTIMATE OF PRICE VARIATION SINCE 1895

NOTE.—The prices of 1900 are taken as a standard of comparison = 100. The prices of the other years are thus expressed as percentages of the prices of 1900.

Year	A Wholesale Prices of 45 Principal Articles	B Retail Prices of Food in London
1895	91·0	93·2
1896	88·2	92·0
1897	90·1	96·2
1898	93·2	100·8
1899	92·3	96·4
1900	100·0	100·0
1901	96·9	101·9
1902	96·5	101·6
1903	96·9	103·2
1904	98·3	104·3
1905	97·6	103·7
1906	100·4	103·2
1907	105·7	105·8
1908	102·8	108·4
1909	104·0	108·2
1910	108·7	109·9
1911	109·3	109·3

It should be explained that both in Column A and Column B the various articles considered are "weighted"—*i.e.*,

due account is taken of the various proportions of them consumed. This is done in order that undue importance should not attach in the calculations to a rise in price of an article which is consumed only in small degree. By taking proper account of the proportions of consumption, the index number becomes approximately a true expression of the rise as it affects average consumption.

If now we imagine the case of a man earning a steady thirty shillings a week from 1895 to 1911, we see how seriously this rise in prices has affected him. In 1911 he drew exactly the same money wage as in 1895, but in 1911 it bought much less than in 1895, and therefore his real wage diminished considerably.

The Wide Differences Between Economic Value and Utility

It will also be apparent from the considerations we have advanced that economic value is not a measure of utility. It is a most important consideration that primary utilities have small economic value. Beginning with the first necessities of organic existence—air and sunshine—we have invaluable utilities with no economic value. Proceeding next to food, we have invaluable utilities which have small economic value. At the other end of the scale we have utilities which can easily be dispensed with, which many people dispense with as a matter of choice, and which yet have a very high economic value. We may instance a ruby, an emerald, or an ancient piece of china. As utilities these commodities satisfy a sense of beauty or a sense of curiosity, but we can exist both comfortably and conveniently without them; many of the highest types of mind esteem them not.

The Diminishing Satisfaction to be Obtained from Great Wealth

It is because the bulk of necessaries are low in economic value, while it is, broadly speaking, only as we approach the luxurious commodities that we get increasing economic values, that there is a *diminishing satisfaction to be obtained from the possession of income as income grows.* For every addition of equal value to an income, the return of satisfaction to be derived from it diminishes. Add £100 to an income of £100, and the recipient is overjoyed, and feels immediately enriched. Add £100 to an income of £1000, and the little more means an almost unnoticeable accretion of satisfaction. Add £100 to £5000 a year, and for all practical purposes nothing has been done—the income in point of *command of satisfaction* is, for practical purposes, unaltered. Going further up the scale, to add even so large a sum as £1,000 to the income of a millionaire is to add nothing to the satisfaction of his wants. These considerations are of the utmost social importance, for in the light of them we understand how comparatively simple a thing it is to add to the satisfactions of the great majority.

In the present development of civilisation, it is probably true to say that in the United Kingdom in 1912 a family possessing £1000 a year can command almost everything worth having that the world's civilisation has to offer. Travel alone, perhaps, is the commodity which it is impossible adequately to enjoy with such an income. Everything else—a beautiful and refined home-place, the means of seeing one's own country and in some measure other countries, good food, good clothes, literature, music, sport, recreation, and every instrument or accompaniment of culture and refinement which appeals to high-minded people—may be commanded.

How Much Increase of National Income would be Required to Make Everyone Rich?

There is great consolation in this consideration, but we must hasten to remind ourselves that such an income, which would not suffice to make its possessor deemed a rich man, is not yet the possession of more than a few even in a wealthy country such as the United Kingdom is commonly regarded as being. To give such an average income to each of our families would call for the magnification of the existing national dividend by about four and a half times—*i.e.*, it would have to be increased from about £2000 millions a year to about £9000 millions a year, assuming values expressed in gold to remain at what they are today.

That is an all-important qualification, of course, for such figures have no significance one way or another, as we have seen, unless we take variation of exchange value as expressed in prices into account. Also, we do well to remind ourselves that probably there are not more than 200,000 families, if as many, in the United Kingdom in 1912, who enjoy as large an income as £1000 a year.

Such considerations are at once a measure of the present limitations of trade and industry, and of the enormous possibilities that lie before them. There is every indication at the beginning of the twentieth century that the scale of incomes will rise considerably long before its close.

The fact that the return of satisfaction from income diminishes as income grows is not only a most important consideration which arises in connection with the theory of value; the national, industrial, and commercial considerations involved are of peculiar importance. The statesman finds in it an incentive to improve the spending or consuming power of the masses of the people, and he sees in the undue accumulation of wealth by a few a misfortune which is not only individual but national, since it confers what is useless or next to useless upon some, and denies what is most necessary to others. The industrial captain realises that trades which depend upon the satisfaction of a limited number of persons possessing considerable incomes cannot be in a satisfactory position in point of magnitude. However rich a man is, his consumption of hats, or boots, or house-place, or table-cutlery, can only be limited. One house gives a certain satisfaction, but two houses cannot give twice the satisfaction of one or even one and a half times the satisfaction of one. Three becomes rather a bore, or even a nuisance, to their possessor as far as individual use is concerned.

The Vast Advantage to Trade of a Wide Distribution of Wealth

Besides, it is really of far more importance to a trade supplying necessities that a large number of incomes should gain a small accretion than that a few incomes should gain a large accretion. If five thousand families each gained £10,000 a year it matters very little to the boot manufacturer. It matters very much more to him if the same amount—viz., £50,000,000—is shared between two million families as a gain of £25 a year each. The latter type of increase would bring much more trade to the boot manufacturer, the former scarcely any.

Passing from this point, as it affects the manufacturer engaged in trades of necessity, to the workman, the latter, it may be observed, earns no more because of the expenditure of the rich than because of the expenditure of the poor. This is a point too often overlooked. The bricklayer engaged in building a second house for a rich man does not earn a penny more than the bricklayer who puts bricks into a workman's dwelling. The woman making hand-made lace to be bought at an extravagant price by a rich woman earns no more, and, indeed, sometimes not so much, as the woman engaged in a factory in making machine-made lace for poor people. The shipbuilder working on a magnificent yacht for a man of great income draws no larger wages than the shipbuilder making a modest tramp steamer which is to carry useful merchandise on the high seas. *The conception, therefore, that luxurious expenditure is good for the poor is utterly fallacious.* The gathering of spending power into a few hands is merely the expression of the deprivation of the power of expenditure of the many, and the result must be to increase trades of little intrinsic utility, to the economic disadvantage of the nation as a whole.

Price—What Anyone will Give for a Certain Satisfaction

From the conception of diminishing return in satisfaction from increasing supplies, sometimes termed the "law of diminishing utility," we may pass to the measurement of utility. The measurement of an economic utility takes expression as price—*i.e.*, as what a person is prepared to give in order to procure a certain satisfaction. The primitive man offered so much corn in exchange for a weapon, or so many cattle in exchange for a wife. Civilised man, using money as an instrument in exchange, offers so much money for the object he desires, and such a money offer is known to modern economists as his "demand price."

The words "demand" and "supply" are very commonly used, and we all have a rough idea of what is meant by them. The most commonly understood of economic laws is that an increasing demand raises price, and that an increased supply lowers price, and we know by common experience that between the variations of supply and demand price comes to a more or less stable equilibrium at any given time. Indeed, price may be defined as the point of equilibrium, as expressed in money, of demand and supply.

The Difficulty of Gauging Price by Judging Supply and Demand

In the common affairs of life, the attainment of the point of equilibrium we call price is, at any given time, a matter of the deepest importance, and a business man is constantly endeavouring to gauge demand that he may meet it, and to foretell supply that he may be able to take advantage of it, to enlarge supply by increasing his production at a lower cost if he thinks that enlarged supply will be met by an adequate increase in demand. At any given moment the factors at work are so numerous and so varied in character that it is exceedingly difficult to foretell

the course of prices in the near future, and it must be confessed that all the thinking and writings of the theoretical economists have done little to help the man of commerce in his affairs at any given moment in this connection.

The most profound of business errors are frequently made through neglect of the possibilities of supply and demand. We may give an illustration of this which will show how easy it is for shrewd men to miscalculate supply and demand.

An Illustration of the Failure to Estimate Demand

It is well known that in 1897 a great miscalculation was made by many London speculators who erected stands on the route of the great Diamond Jubilee procession in London, in the hope that they might let them at high prices to well-to-do people. The construction of a temporary stand to seat human beings is very costly, because, as it has to be made strongly enough to bear a great weight for a little while, it has necessarily to be made strong enough to bear that weight, if necessary, for many years. That means that heavy timbers have to be employed, and that they have to be carefully planned as to strains. Not realising that, although this is a rich country, the number of people in it able to afford a high price for a seat for a few hours is actually small, quite a number of seat speculators in 1897 were faced with a heavy loss. What they did was to miscalculate demand, and to put on the market far more seats than could be absorbed at a high price. Years went by, and another occasion arose for a great Royal Procession—we refer to the Coronation of his Majesty George V. On this occasion, with the proper idea of gratifying as many citizens as possible, the processions extended over two days, and very long routes were chosen. As the routes were so long, it followed that an enormous number of windows faced the routes, affording seats without the erection of stands.

The Persistence of Unsound Estimates and the Resulting Punishment

In spite of the experience of speculators in 1897, a large number of persons thought to make huge sums of money by erecting special stands. At all parts of the long routes we saw erected at enormous cost timber structures of the most costly character, and large sums of money were asked for a single seat upon them. It proved to be a ridiculous miscalculation of demand and supply. Hundreds of thousands of persons able to afford a guinea, or two guineas, or three guineas, for an hour or two's amusement were not forthcoming, and in some cases the seat speculators found themselves compelled to accept less than the cost of their stands in order to obtain customers.

If we see error thus manifested in a case where there need not have been such grievous miscalculation on the part of business men, it is obvious that in the ordinary case it is very difficult indeed to foresee the results of the play of supply and demand even a little while in advance. Suppose the problem to be—What will be the price of wheat in twelve months' time? We can reckon with near accuracy that the lapse of twelve months will add so many to the world's population and, in particular, so many to the population of countries which consume wheat. We may perform that operation with fair accuracy, but on the side of supply we are at a complete loss. The price of wheat in the world at any given time is an equilibrium arrived at by supply and demand in the world at large, and on the side of supply it is absolutely impossible to form any sort of idea in advance as to how the harvests of the many wheat-producing countries will turn out.

The Wavering of Rubber Prices as an Example of Doubtful Forecast

Or let us consider the case of a material such as rubber. At the end of 1912 the course of the price of rubber in the future is very uncertain. A few years ago there was a time of great scarcity, owing to a greatly increasing demand denuding the world's naturally growing supplies, and bringing about almost a famine in the commodity. That famine was followed by a rush of capitalists into the industry, and rubber plantations were extended in every possible direction. Vast sums of money were sunk, some wisely, some foolishly. The result has been greatly to extend the possibility of production, and rubber has fallen from its scarcity level to a point which is still much higher than it was fifteen or twenty years ago. Anyone endeavouring to gauge the price of rubber in the future has to endeavour, on the one hand, to gauge the course of demand—viz., the probable growth of the motor-car, cycle, and other rubber-using industries, and, on the other hand, the probable supply by the largely increased area under rubber cultivation. The task is impossible, and most varying opinions are expressed by people who have

studied the subject. As a consequence, the market for rubber shares wavers a good deal, looking to the price of rubber, and wondering whether demand or supply will take the lead.

It is not difficult to make "long-run" forecasts in such matters, and we may be pretty sure that, again to refer to the same example, rubber will some day fall very greatly in price. The practical difficulty as a matter of forecast is to decide when that great fall will take place—whether it will be next year, or in two or three or in ten years' time.

Very striking are the changes produced by the variations in supply and demand when stock markets are affected by a war panic. Take, for example, the effect produced in the world's stock exchanges by the news of the outbreak of war in the Balkans in October, 1912. Large numbers of people were induced to throw their holdings on the market in the course of a few days, and we witnessed a sudden tumble of prices. Never was a better illustration afforded of the distinction between intrinsic value and market price.

The Absurdity of Panic Sales by Short-Sighted Investors

The stocks of many concerns which were not only thoroughly sound and thoroughly safe, but which were in the heyday of their prosperity and rapidly increasing their profits, fell suddenly in price. The fall here was not only not because the firms had failed, but in spite of the fact that they were increasing their profits. The price of the stock on the exchanges, however, was immediately governed by the fact that there was a crowd of sellers and no buyers, and the price fell in defiance of the intrinsic value of the undertakings. Periods such as this are, of course, largely availed of by long-sighted persons with deep purses.

In the case of normally cheap articles such as the common foods—corn, sugar, fish, etc.—the production of an unusually large quantity may make it go very hard with the producer owing to the effect of a superabundant supply upon price. We have had this illustrated again and again. There have been takes of fish so great that large quantities have been destroyed in order to keep up the price of fish in the market. At any given time the demand for this particular kind of food is actually great, but relatively limited. If, therefore, at any particular time, three or four times the average amount offers, demand truly is increased by the lowering of price, but demand is more than satiated, and price accordingly falls so low as to be ruinous to the producer. Cases have occurred, too, in which fruit has been so abundantly produced as to make it not worth while to gather the entire crop, for if it were all gathered so much would be offering that the price would fall below a point at which it would be remunerative.

The Effect of Greater Demand in Sending Prices Up and Down

The relation of supply to demand is a matter of action and reaction, and although an increase of demand may immediately produce a rise in price, it may lead to a fall in price by stimulating a better supply. For example, the spread of education which took place after the invention of printing brought into existence a large potential reading public, which public, however, was not able to satisfy its demand for reading because of a limited supply. For long, books remained dear. Presently it began to be suspected by publishers that the potential demand existed, and more and more enterprising endeavours were made to supply it. As these endeavours proceeded the demand rapidly increased, but that demand, instead of raising price, spurred publishers to more enterprise and inventors to the improvement of printing appliances. Action and reaction between supply and demand has proceeded very rapidly in the publishing trade, and, while demand has always been increasing, prices have been, down to 1912, always falling, until we have reached the stage at which cloth-bound novels can be bought for sevenpence, and splendidly printed newspapers for one halfpenny.

Cost of Production as an Element in Supply

But, it may be asked, has, then, the cost of producing an article no relation to its value? Is a producer compelled to take a price which is arrived at quite independently of his costs? The answer to this question is that the *cost of production is an essential part of the conditions of supply*, and that when we speak of demand and supply we use the latter term as conditioned by cost of production. At any given time, it is true, the price of an article is the result of the play of demand on the one hand and supply on the other hand, but it is clear that no producer would continue to add to supply unless his work was remunerative. We have already given a striking illustration of this in the destruction of fish by fish

producers. If the producer finds himself putting out a certain commodity so liberally that he overtakes demand and reduces market price below a point at which he can gain what he considers a due remuneration, he must either go out of business or take measures to reduce the supply. It is, of course, only in the case of crops that such measures as destruction come to be resorted to. The natural forces are sometimes against the cultivator, and sometimes too heartily with him, and when the owners of orchards find their trees so overloaded with plums that the market is likely to be glutted with them, they have no recourse but to keep part of Nature's bounty out of the market. In the case of manufactures, of course, such unexpected gluts do not, in the nature of the case, occur, and no manufacturer will produce unless he thinks he can see his way to the customary profit.

If, owing to the prospect of making exceptional profit, a large number of new capitalists come into a trade and begin to supply the market, a point is soon reached at which it becomes unprofitable to produce, through the additional supply causing a fall of market price. As soon as the point is reached at which the additional capital used tends to render its employment unprofitable, a certain amount of capital comes to be wasted, and a profitable equilibrium is again attained.

The Modern Power of Manufacturing more than is Asked for

During the process the attempts to make a profit in spite of a fall in price may lead to the employment of more economic methods, and we may see a fall in price on this account. It is in this connection that there have arisen the efforts to exercise an artificial control of supply, and therefore of price, which we examined in another aspect in the last chapter. There can be no doubt that in recent years the means of producing things have increased much more rapidly than the power of consumption. It is a very facile process now to produce more hats, boots, bicycles, watches, earthenware, saucepans, furniture, etc., than the mass of the people can possibly consume, owing to their restricted incomes. The means of producing does not wait upon income, and the inventor does not pause in his efforts because so many people are poor. Between the extraordinary facility of mechanical production and the power which now obtains of wielding great masses of capital, the satiation of a market up to a point of possible demand becomes an easy possibility. That is to say, *the manufacturers in almost any great trade that can be mentioned now possess the power of overtaking consumption at any time they care to do so.*

Obviously, if they exercised the power which they possess they would put themselves in the position of the fruit-farmer with a too abundant crop of plums, or the Brazilian coffee-planter with a too great supply of coffee thrust upon him by Nature.

How the Necessity for Profit Curbs too Lavish Production

Suppose a group of capitalists in the United Kingdom set to work with a capital of many millions, employed some tens of thousands of men, produced cheap watches by the American method, and offered them on the market just as rapidly as they could turn them out, regardless of consequences. What would be those consequences? There are only about 26,000,000 adult men and women in the United Kingdom, and it would not be long before the gigantic watch factories turned out far more than 26,000,000 watches. Even if we added boys and girls down to ten years of age, we should only add a possible market which would soon be satiated by our hypothetical watch capitalists. Further, even if every baby were given a watch to play with, the limits of watch manufacture would obviously be within the United Kingdom the supplying of a timekeeper to every person. Long before that point was reached, the price of watches on the market would have fallen so low that the watch capitalists would be producing at a loss. The law of supply and demand would be too much for them. In practice such a thing never occurs, because the supply of capital and labour ceases as soon as the work of a trade puts forth such an output as to make the price fall below a point at which profit cannot be earned.

The Attempt to Limit Output to Prevent Prices from Falling

That is why it is that there is a common-sense relation between the amount of capital and the number of people engaged in an industry on the one hand, and the size of the market for the production of the industry on the other hand. No one ever measures up the number of people requiring a commodity, and the amount of capital likely to be wanted in an industry, and then applies the latter to the former. The rough-and-ready process of business operations is that people enter a trade to seek profit, and it is only by

experience—sometimes bitter experience—that the equilibrium of supply and demand is reached.

We can see very clearly, then, why so many efforts have made themselves manifest in recent years on the part of business organisers to control or maintain price by deliberate restriction of supply. It has been brought home to trade after trade that the power of production within the trade is so great relatively to the exhibition of demand that we see heads being put together in order to limit output and so prevent price from falling. We have, in view of the widespread character of this price maintenance factor, to revise our conceptions as to the play of supply and demand in an open and competitive market. It is just as true when there is no competition as when competition exists that price is determined by an equilibrium of demand and supply; but we have the all-important difference that where there is monopoly *supply is artificially controlled.*

The Strife Between Competition and Monopoly and Possible Effects on Prices

When there is competition, the equilibrium is arrived at by forces in which all the members of the trade are factors, no one of which is able to exercise more than a fractional share in the general result. Where there is monopoly, the monopolist is able to determine the conditions of supply after calculation of the probable demand at various prices, and he is able to play a very important part in price determination.

It should not be imagined, however, that it necessarily follows that if an industry is monopolised it will charge higher prices after the monopolisation than before. Certainly higher prices must result from the monopoly if the monopoly itself effects no economies in cost. As a matter of fact, however, monopoly gets rid of many costs which are otherwise absolutely necessary. After monopolisation, the managers of a monopoly may be able, through economy, to save so much in cost of production that their price, although an artificial monopoly price, is actually lower than the lowest competitive price that could be charged before the monopolisation.

This is claimed to be the practical result of their operations by the managers of one British Trust—one which need not be particularised, but which is concerned with an article of very common consumption. When charged with running a monopoly, they admit it; but they contend that they have not raised price, and that prices are lower than they would have been if their monopoly had not been formed. It is impossible to decide upon the accuracy of this contention without an examination of the facts, which it is not possible for outsiders to make; but it must be admitted that the statement is not inconsistent with possibility.

Cases in which Increased Demand Decreases Cost and Price

It should be borne in mind that, when we speak of cost of production here, we include cost of distribution or of selling as well as cost of actual raising or manufacture; and of course it follows that if cost of distribution is reduced, it is just as tantamount to a reduction in cost of production as though a new machine had been invented to produce an article with a decreased output of labour.

We have said that increased demand does not necessarily produce increased price. It is useful to note in this connection that whether or not demand increases price depends upon a condition of an industry in point of profitable returns. It will be apparent that there must be in the case of every industry a period of development, more or less prolonged, during which, as output increases, costs fall. If, therefore, an increased demand arises in an industry which is in such a condition that costs fall through increased production, we see how possible it is that the increased demand may enable a manufacturer to produce more cheaply, and therefore actually to lower price in spite of increased demand.

The Economic Principle Illustrated by the Photographer's Charges

A very elementary illustration of this may be found in the order one gives for a photograph. If we trouble a photographer to make a negative, and order only one copy to be taken from the negative, it is obvious that the photographer must charge us for the single copy all the costs to which we have put him, plus a reasonable profit. If we order a dozen copies, a large part of his expenses remain the same, and, although our demand has increased twelve times, he is able considerably to lower his price per copy. What is true in this illustration of a small-scale transaction may, it will be seen on reflection, be true of a trade of considerable dimensions. The doubling of demand may enable such economies to be effected as to enable the price *per article* to be lowered. It is necessary to note, however, that if we imagine the photographer to be a monopolist, and we could have recourse

to no other photographer, then he could charge as much each for a dozen copies as for one copy in spite of our increased demand.

As soon, however, as a point is reached at which no further economies can be effected through increase of production, increase of demand must cause an increase of price.

In a case where "increasing returns" from an industry are possible through larger demand, the normal course resulting from increased demand are, first, an immediate rise in price through the increased demand; next, the stimulation of production through the higher price; third, the production at lower costs; and then, assuming the presence of competition, the lowering of price. So action and reaction may proceed indefinitely, while yet there is an unsatiated demand capable of being expressed in purchasing power, and while it is possible to effect economies in cost through larger output.

Are Business Monopolies Helpful or Hurtful to the Whole Nation?

The importance of the considerations which attach to the modern Trust and monopoly movement cannot be exaggerated. We can see that whether or not a modern business monopoly is hurtful to the economy of a nation depends entirely upon the wisdom with which it is governed. It is impossible to deny that if the managers of a monopoly agree to restrict the supply which is within their powers they can effectively tax the people of a country if, of course, there is no foreign competition. They may make undue profits and stay the development of an industry by relying upon monopoly for their gains, and neglecting to apply to their trade economies which would be forced upon firms in competition with each other. We can, however, imagine an ideal monopoly, the managers of which would be continually experimenting on the technical side of their business in order to reduce costs of production and distribution. If they did so, exercising a great mass of capital, they would be in a position to lower costs, and, indeed, in a much better position to do so than any group of competitive capitalists could be, taken as a whole.

If we consider, say, one hundred capitalists engaged in a manufacturing business, we see them each endeavouring to excel, and in that endeavour making small monopolies of various patents connected with the business, firm A possessing one or more patents, firm B possessing one or more different patents, and firm C, again, owning yet a third set of patents. As a result, firm A would be able to offer the consumer one particular excellence, firm B would be able to offer a second, firm C a third, and so on, but from no one firm out of the hundred could one obtain all the latest devices of the trade. This is the case that actually obtains in more than one industry.

The Ideal Monopoly for the General Benefit of Mankind

If the trade is monopolised, however; and if in the case of our hypothetical ideal the managers of the monopoly have the power to bring to bear all possible improvements in the trade—and we need only repeat here briefly what we have said before at some length, that they are able to effect economies in management and so forth which are obviously impossible to competitive firms—we see that such an ideal monopoly, contenting itself with a good but reasonable profit, could undoubtedly put at the disposal of a nation, or of the world, advantages superior to those offered by any competitive group of capitalists.

In practice it is to be feared that the monopolists do not give us this ideally possible result, and one of the greatest problems before the world at the present time is the reconciliation of the growth of monopoly with the interests of the great masses of the people. We have, in short, to solve the problem of most effective supply on the one hand, to meet, on the other hand, the realisation of the maximum demand. On the one hand, the economy of supply will undoubtedly be worked out to a point at which it will be possible, if thought desirable, to produce a practically unlimited quantity of commodities of any particular kind.

The Good Day Coming when Men's Extended Needs will be Satisfied Abundantly

On the other hand, we need not hesitate to believe that the translation of potential into actual demand, which means the magnification of existing consuming power to a degree such as is as yet possessed by but few people, will also be achieved. When those things are secured, discussions of value will have a very different significance, and, indeed, with the existence of a common plentifulness, they will lose their importance, and we shall all be able to see the essential differences between the natural wealth that men can really use and so actually enjoy and the uneconomic views of wealth and prosperity that now satisfy many who pride themselves on being practical but have not grasped the simplest scientific principles of trade.

THE WORKLESS FLOTSAM AND JETSAM OF CASUAL LABOUR GATHERED ON LONDON BRIDGE

THE STATE AND THE POOR

The Story of the Collective Treatment of the Poor, and the Change of Men's Attitude Towards Them

REPRESSION, RELIEF, PREVENTION

In Chapter 21 of this work we discussed some of the broader problems of poverty as they arise in the modern world, a general discussion that may be supplemented by the story of how poverty has been treated in the past by the community, and how it is likely to be grappled with in the future. That story is one of changing economic conditions, no doubt, but still more is it a story of change in the mental attitude of men towards their fellows.

Indeed, any study of the action of human society as a whole, through law, upon the condition of the less fortunate members of that society, whether such study be pursued in the region of crime, or of disease, or of indigence, arrives at the fact that only within quite modern times have serious, thought-out, comprehensive, reasoned attempts been made to understand and eradicate the ills which the commonwealth has inherited. Mankind have been muddling along in a matter-of-course way, without realising their difficulties on a broad scale, until, now and then, those difficulties have grown acute, as when plague has brought all health into jeopardy, or disorderliness has made all life unsafe, or poverty has threatened to destroy all financial stability; and even then the community has been well content with palliatives, not having had the grasp of experience and knowledge that would plan a far-reaching remedy. That is what has happened until quite recently with regard to poverty. Innumerable Poor Laws have been contrived; but a deliberate grappling, on something like scientific lines, with poverty, as with other social evils, has been postponed to the last eighty years, and is only now being practically realised as a necessity.

Cogent excuses may be made for this delay, for no question has divided men's opinion more sharply than poverty and its relief. To this day there are deep national cleavages on the main question whether the relief of poverty is a civil duty at all. The law of Holland, for example, declares that it is not a civil responsibility. That view is an inheritance from the ages of charity, when the economic organisation of life was comparatively simple. While such fundamental differences of opinion exist, one cannot wonder that a scientific treatment of the causes of poverty has been delayed.

Then, too, poverty in all times and places is a relative condition. No hard-and-fast rule will fit it. Is a native of the South Sea Islands poor while he can live, without clothes, in a beautiful climate, by plucking a nut from a tree? Mr. Seebohm Rowntree defines poverty as the state of families "whose total earnings are insufficient to obtain the minimum necessaries for the maintenance of merely physical efficiency." The demands of that efficiency obviously depend upon where the people concerned live and what they have to do. The British workman could not work on the South Sea Islander's cocoa nut. The conditions of poverty are in a large degree local, and generalisation does not help us, but brings confusion. The question, indeed, can be studied best in the most highly organised State, for the chief economical difficulties arise out of the organisation demanded by civilised life. Such a country as England, therefore, with its growth from agriculture to manufactures and commerce, furnishes the best field for study, because the range of its conditions of work and living is complete.

In a primitive state, when practically the whole population is associated closely with agriculture and the earth's direct productivity, charity, supplemented by the family and clan feeling, may serve naturally to

ward off the effects of poverty. The means for the relief of hunger are close at hand; and the impulse to give in kind is so elemental that it persists long under quite different social conditions. Even the most stingy people who would not give money of the smallest value to the beggar will give bread. There is a deep-seated belief in the hearts of all that no one can be doing wrong in giving food for instant wants. While the organisation of Society remained simple, this feeling sufficed for the allaying of such poverty as prevailed, where the very poor were few and the very rich almost non-existent. It suffices still in the rural parts of some lands. In mediæval days it found a sort of organised expression through the monasteries, which dispensed hospitality without attaching to it an undignified personal obligation. Even yet people feel they can take from a monastery without being shamed, though they are better able to assist the hospice than it is to assist them. The vague and beautiful relations of courtesy, hospitality, and charity, before the days when

> The giver may not give, lest any blame him,
> And the taker may not take, lest taking shame him,

were well enough in the childhood of the world, while human intercourse was personal throughout all society, and mutual and cordial understandings pervaded a whole country-side at once.

The Failure of Charity in Keeping Pace with Civilisation

But that idyllic state became broken up in our own country by war, by pestilence, by new economic combinations, such as the grouping of men in masses for manufacturing purposes, and by the extraordinary subdivisions of labour which have followed the use of machinery, and have made men skilled in small sections of work, and unskilled in all else. The personal relationships have failed with the growing complexity of life, and they must be replaced by a new, collective, wisely-generalled humanity, if the poor are not to suffer, and perhaps increase. The passage from the old to the new during the last three hundred years has been marked by grievous strife, experimenting, and mistakes, which we may follow with painful advantage if it helps us to clear the future from the proved impediments of the past.

The relation between the State and the English poor, as set forth in our laws, has undergone four great changes since history had a full record, and it is on the eve of a fifth. There was the period before Queen Elizabeth, when repressive measures were tried, and, failing, gradually became merged into voluntary relief. Then there was a compulsory system of relief, organised locally, and lasting for more than a hundred and fifty years. But this plan could not accommodate itself to the vast economic changes which came with mechanical invention and the use of steam. Indeed, it proved a source of demoralisation to the point of national danger before it was superseded by the modern Poor Law system—a great advance, but lapsing into admitted inadequacy after nearly eighty years of use. The fifth period asks insistently to be begun, without at present eliciting any response from too busy Governments. We wish to look at these successive stages of experiment in more detail.

The Attempt to Suppress the Signs of Poverty by Force

The most ancient laws for dealing with the poor are predominantly, if not entirely, repressive. Where poverty reached a stage that called for public notice, it was regarded as bordering on the criminal, and was confounded with begging and vagrancy. The giving of indiscriminate alms was forbidden, and anyone found offending could be fined ten times the amount he had given; but by the reign of Henry VIII. it had become necessary to define the "poor creatures" who could properly be "holpen," and those who might live by charity were registered and licensed within certain limits, while "valiant beggars" able to work were subjected to additionally stringent penalties. The law sought to punish those who did not work, and to make them work, be they young or old.

Drastic Laws that Failed in the Repression of Vagrancy

Thus a statute of Henry VIII. (22 cap. 12), which remained in force for sixty years afterwards, ran that any person, "being whole and mighty in body, and able to labour, having no land master, nor any useful merchandise, craft, or mystery, and who can give no reckoning how he doth get his living," shall be brought before the Justices of the Peace, who, "at their discretion, shall cause every such idle person to be had to the next market town, or other place most convenient, and there be tied to the end of a cart, naked, and be beaten with whips throughout the same town, or other place, till his body be bloody by reason of such whipping; and after such punishment he shall be enjoined, upon his

oath, to return, forthwith, the next straight way, to the place where he was born, or where he last dwelt the space of three years, and there put himself to labour, like as a true man oughteth to do."

If he was caught a second time begging while able to work, he must have a hole bored through the gristle of his right ear—the instruction in a later renewal of the statute being that the instrument must be a hot iron, and the size of the mutilation "the compass of an inch about." For a third defence he could be put to death, "as a felon and enemy of the commonwealth." Under the same statute "all idle children" over five years of age could be "appointed to masters of industry, or other craft or labour, to be taught."

When Slavery was a Punishment for the Saucy Child

These laws were made more stringent in the reign of Edward VI., the vagrant, for a first offence, being branded with the letter V; for the second offence with the letter S (slave); and the third penalty was death. Anyone could take away the child of a "loiterer and idle wanderer," and bring it up till twenty, if a female child, and till twenty-four if a male, and appropriate the produce of its labours; and if it should at any time resent chastisement by its master, the penalty was that it should remain a slave for life.

This statute, be it said, for the relief of that age from some measure of odium, only remained in force two years, but it shows the governing spirit of the period.

The punitive laws, with forced apprenticeship, and fixed wages for which every man must work when work was demanded of him, of course, proved ineffective, and presently—in the reign of Henry VIII.—arrangements were made for voluntary alms to be contributed for relief of the poor, after persuasion, on Sundays and holidays; but, this being a failure, collections for "the poor in very deed" were made compulsory in the reign of Elizabeth, with possible imprisonment for non-compliance.

A Poor Law that Remained in Force for Twenty-Three Decades

Later, shortly before the death of the great queen, the Poor Law, as it has been known ever since, was in essence established—that is to say, in each parish all the inhabitants were taxed compulsorily, overseers of the poor were appointed, and arrangements for collecting and distributing the funds were made. Work was to be provided for those who could work, and relief was to be given to those who could not work. Poor children were to be trained to some handicraft, and the idle were threatened with punishment. The difficulty, of course, was in finding work when workmen could not find it for themselves—and that difficulty was never overcome.

The Elizabethan law remained in force, with modifications, till 1834, but became less and less fitted to deal with the needs of the country as industrial conditions changed, until during fifty years preceding the Poor Law of 1834 it became gradually swamped by gross abuses. Early in the eighteenth century (1723) the distribution of the funds gathered under the overseers' levy had become so unsound that indoor relief had to be insisted on as a safeguard, and the applicants were "offered the House" as a test of the reality of their poverty. The parish apprenticeship system became a scandal, and a law was passed for the protection of apprentices. But the full inadequacy of the scheme was not revealed until, towards the end of the eighteenth century, three great disturbing influences came simultaneously into operation.

The Changed Economic Conditions that Overthrew the Elizabethan Poor Law

These were, first, the Enclosure Acts, which dispossessed the rural labourers of their common rights and made them wholly dependent on their daily wage. The law that there should be four acres of land to every cottage was repealed. The change of the land into pasturage reduced the number of labourers needed, and such as were left largely lost their share in the land through the Enclosure Acts. Between 1710 and 1760 only about three hundred thousand acres were enclosed from the commons, but between 1760 and 1843 nearly seven million acres were enclosed.

Simultaneously with this restriction of rural labour a second great change in urban employment and village industries was going on through the invention of machinery and the use of steam. Hand labour of all kinds was superseded, and could not be absorbed by the new forms of manufacture, nor could it readily adapt itself to any of the requirements of the period. At the same time such labour as had a chance in the industrial or agricultural market could not defend itself by combination, for all united action on the part of workmen was forbidden as conspiracy by the law. This throwing out of workmen, by shrinkage and change in employment, was accompanied, too, by a great rise in the

price of food, owing to the French wars and the cruel Corn Laws in aid of the British landed interest. No wonder that, under such conditions, the arrangements for providing for the "poor in very deed" broke down hopelessly.

The deadlock, too, was made the worse by the incredibly unsound action of the people in whose hands the administration of the Poor Laws fell. In 1782 the Justices of the Peace were made the Guardians of the Poor. They proceeded to help themselves at the public expense in a manner that sounds incredible now. A wage was fixed for labourers according to local custom, and in so far as that amount was not reached by the wage paid by the farmers the difference was made up out of the poor rate. To the labourer who did not mind being on the poor rate it mattered little how he received his weekly sustenance, whether in wages or supplementary relief. To the farmer and landowner the temptation was to pay as little as possible in wages, and to get from the ratepayers as much as possible through the levy in relief of wages. The manufacturer was in the same position, and indeed he was often actually subsidised by the parish authorities to take pauper apprentices off their hands, and so put in his pocket the whole proceeds of their labours, and a bonus besides.

The Days when to be a Pauper was to be Comparatively Well Off

Meantime, the ratepayers who did not happen to be employers paying less than the market rate of wages had to make up the wages from the underpaying employers through inflated poor-rate contributions; and the independent labourer who would not draw money from the parish had to compete with men whose wages apart from the parish supplement —were below starvation level.

That was the period when it was said that, poor as was the diet of the pauper, the diet of the small ratepayer was poorer still, and the diet of the independent labourer was poorest of all. The condition of many country places, in short, was that every working man was "on the parish."

From this state of impending public bankruptcy, brought about by bad economy and the lack of adaptation of the Elizabethan Poor Law to the changing needs of the times, the Poor Law of 1834, which still is in force with modifications, rescued the nation. Indeed, the working classes were wallowing in debt and slavery, their spirit of independence and of hope undermined, it might be suspected, for ever. When we say that the Poor Law of 1834 has proved itself inadequate, and that it, too, must be superseded, let us not forget from what a slough of despond it helped to rescue the nation's wage-earners.

Repression and punishment for poverty had failed; a policy of profuse relief—profuse in the aggregate, though not in individual amount—had failed; and an inquiry, conducted with thoroughness and candour for years, arrived at the conclusion that what was needed was the establishment of the principle that the condition of the outdoor pauper should be below that of the poorest independent labourer.

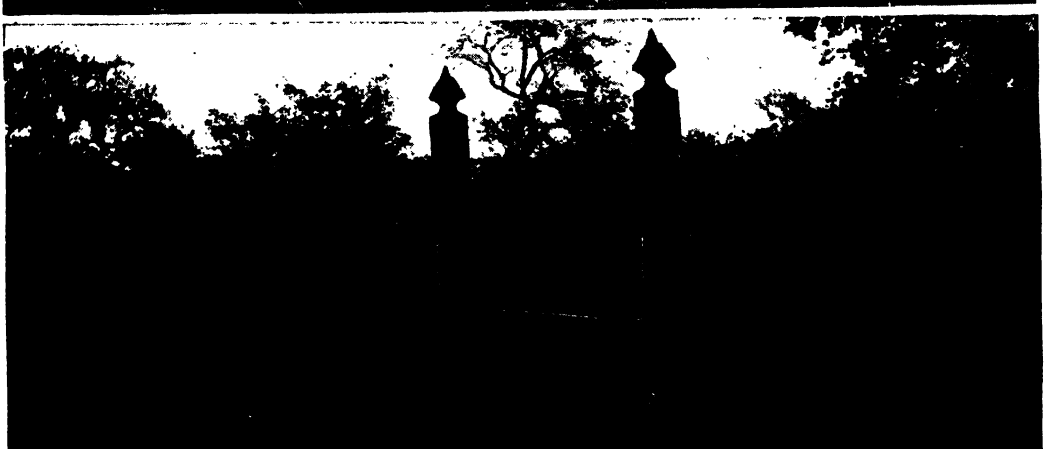
Provisions and Good Effects of the Great Poor Law Act of 1834

It was recommended that outdoor poor relief should be checked; a central authority should be established for administrative control with a view of securing uniformity in management; that unions covering wider areas should be the unit of management; and that the system of accounts should be made clear and sound. These recommendations, embodied in the Poor Law Act of 1834, really made administrative rather than legislative changes. They still kept *relief* as the principal aim of the State in dealing with the poor, but combined it with attempts to deter people from accepting that relief. In fact, the new administration aimed at making pauperism unpopular instead of general. In that it succeeded. Except with a section of people who were morally submerged and had lost self-respect, the workhouse became an object of execration. In a limited sense this was a good effect, for it built up afresh the character of the thrifty poor. But as time went on, and economic and social conditions changed and enlarged, it became clear that the Poor Law system of 1834 was utterly inadequate for the satisfaction of either the just needs of the poor or the conscience of the community. It penalised some sections quite unfairly; it was weak on the side of prevention, except by making pauperism distasteful; and it did nothing in curative directions.

Changes of Evolutionary Humanity that Make the Poor Law Out of Date

Before the great Commission of 1905-1909, the Guardians of the Poor and the nation generally had begun to realise that many modifications were needed; and, indeed, as far as the law would allow, such administrative modifications were in many places put into force. It became clear that

GRIM REMINDERS OF OLD-TIME "JUSTICE"



A WHIPPING-POST AT TWYFORD, AND STOCKS AT HAVERINGLAND, NORFOLK

From photographs of existing relics of primitive punishments, by courtesy of Mr. T. D. Atkinson.

a great deal of the poverty dealt with by the Poor Law was created by social conditions, and that its victims deserved sympathy rather than repression through stern stultification by institutional treatment. The idea spread that, though poverty was an extremely complex economic problem, which no age had solved, a good deal might be done by way of prevention and cure, and in that hopeful spirit the Commission met, took voluminous evidence, and, after gathering a library of facts, reported in two well-reasoned treatises.

Such questions as the relief without shame of the aged poor had already been settled by the public conscience, and now is settled by law. The separation of children from adults, and their education away from the tainting conditions of pauperism, had been effected by intelligent, humane, and truly economical Boards of Guardians. The medical care of the sick and of lunatics had received the attention that could not well be denied. The indiscriminate herding of all kinds of dependent people together, irrespective of character and antecedents, had been abolished by the most active boards; and so this new spirit lightened considerably the work of the Commission.

Some Striking Facts Found by the Last Great Poor Law Commission

That Commission has gathered an abundance of information for any Government that may wish to realise some of the ideals which shaped themselves in the minds of the Commissioners. Here are a few of the findings. The verdict of history in relation to pauperism is confirmed—namely, that it is much easier to cause it than to cure it. Half of it comes from, or is accompanied by, sickness. The physical condition of the pauper type is very low. No small share is contributed to by bad housing. A fifth of a million people are dying of tuberculosis alone. Drink is the greatest moral disintegrator, as seen in workhouse effects. In one workhouse with 416 inmates, no fewer than 205 could not be allowed out without the anticipation that they would return "in liquor." Unwise relief is a prolific cause of pauperism, for why should the loafer work, he asks himself, if he need not? Chiefly however, preventable poverty, it was agreed, depends upon conditions of labour, and upon the untrained and unskilled state of a large body of young men, fed from the great reservoir of casual boy-employment.

In many of their conclusions the majority of fourteen and the minority of four agreed. They all rejected the mixed workhouse, with its thoroughly unsound simplicity of treatment. They all saw that family life must be kept as the groundwork of action. They all admitted that "made" employment, as on relief works, is bad in its ultimate effects. They all expressed a belief in insurance against unemployment. And they were all convinced of the need for placing certain unemployable people under restraint for their own benefit and that of the community. But when the question of the organisation of future safeguards against poverty arose they differed as to the means.

Where a Commission Widely United Agreed to Differ

The majority wished to establish a "Public Assistance Authority," consisting half of County Council members and half of co-opted members, with local committees, in the existing union areas, to classify applicants and give them "institutional" or "home" assistance as the case might require. Labour Exchanges, education of the young for industrial life, the regularisation of employment through Government and public works, unemployment insurance, with labour colonies for vagrants, were recommended. But the minority contended that a better organisation would be formed by using the present county and municipal authorities, drafting the different classes needing help to the different existing committees, as the sick to the health committee, the young to the education committee, the aged to the pensions committee. They recommended reduction in the hours of labour as a means of absorbing surplus labour, and the undertaking of great beneficent public works to be carried out in times of slack employment. They attached much importance, too, to the establishment of a Ministry of Labour.

The Task that Confronts some Strong, Wise Social Statesman

The keynote of these recommendations, whether in the Majority or Minority Report, but particularly in the latter, is that business enterprise must so plan its operations as to regularise labour, and labour must be so trained as to graduate in competence, instead of being below a certain level prepared only for "chronic destitution tempered by odd jobs." When some statesman is bold enough to tackle the Poor Law he will find abundant material that may be used in rearing a great preventive scheme, such as the past, blindly feeling its way, has never been able to contemplate.

PREVENTIVE EUGENICS

A Survey of Physical Disasters Transmitted from Parents to Their Children

THE DISEASES THAT POISON THE RACE

We now come to preventive eugenics, the fight against racial poisons which are ever tending to turn worthy into unworthy stocks. This question did not enter into the scheme of eugenics as propounded by its founder, Sir Francis Galton, and only very slowly has it been possible to convince Eugenists of its importance; indeed, in this country we still lag behind, though the case is far otherwise in America, and also in France, where certain of the racial poisons are doing terrible dysgenic work. But, once we recognise that these poisons exist, we are bound to admit that the protection of parents and possible parents—above all, therefore, the protection of adolescence—from their influence is a branch of eugenics. It may turn out to be by far the most important, and not the least practicable, of those branches.

The practical methods to be pursued in this great department of Race-Hygiene, as the Germans call eugenics, will be various; they must largely be legislative, and also in part educative, the proportions between the two kinds of methods being very different from what obtain in the case of positive eugenics, where we concluded that legislation could do relatively little, and that education of public and private opinion, influencing the personal conduct of individuals, was all-important.

The case here is different. We can only understand it, however, by dealing with the principal racial poisons one by one, for they are very various and require various means for dealing with them. For the convenience of memory, and the sake of an orderly system, we may classify the racial poisons as *inorganic*, *organic*, and *organised*. Lead is an example of the first, alcohol of the second, and the *spirochæte pallida*, the minute animal parasite which produces syphilis, is an example of the third.

This parasite, and the few others which we believe to injure the offspring as well as the individual, act, of course, not by their mere mechanical presence in the body, but by the poisons which they produce. And no matter whether the racial poison be lead, alcohol, or a toxin produced by a microscopic parasite of disease, the usual feature of its action is that it circulates in the parental blood, whence it reaches the racial tissues or germ-plasm, which it injures. We may guess, though we do not know, that in most cases the injurious action of the poison will be exerted upon the process of "gametogenesis," as the biologists call it, the making from the germ-plasm of the final "germ-cells" which are to be the beginnings of new individuals.

The famous German student Professor Forel, who was for long Professor of Morbid Psychology in the University of Zurich, and had many opportunities of studying the causes of insanity, came to the conclusion, many years ago, that alcohol, above all, can poison the germ-plasm. To this process of germ-damaging he gave the name, often used by writers today, of blastophthoria. To him, by long priority, must be awarded the credit of having insisted upon the occurrence of germ-cell-poisoning or blastophthoria. The present writer has merely introduced these considerations into the purview of eugenics, and seeks to coordinate the existing *data* on this obscure subject, in order that we may be able to banish its consequences from the life of mankind.

Before proceeding, we are to understand that the occurrence, or the degree, of racial poisoning cannot be estimated from the condition of the individual in and through whom it may be occurring. The individual, and notably the nervous system of the individual, is one thing; the germ-plasm

of which that individual is the host is another. The individual's nervous system may show symptoms of, for instance, unmistakable alcoholic intoxication, though the germ-plasm within that individual may be quite unharmed. On the other hand, the individual may show no signs of intoxication, but his or her steady, inconspicuous soakage with alcohol may be producing a "blastophthoria," or poisoning of the germ-plasm, of the most certain kind.

The Most Deadly of the Racial Poisons of Industry

The metal lead is a suitable poison to study first. The complexities of infection, or of toxin and antitoxin formation, are not involved, and, except in the case of very few persons, no prejudice requires to be met in dealing with the facts. In the parallel case of alcohol, we have substantial vested interests and personal prejudices to deal with. Therefore we may deal with lead first, and thus make the way easier for our study of alcohol.

Lead is the only important member of the group of substances which we may call the racial poisons of industry, though arsenic, phosphorus, mercury, and copper perhaps may be included in the same category. For all, or nearly all, of these substances, it has been proved that they may reach the offspring from, at any rate, the maternal organism. Fortunately, their importance is technical rather than practical. Not so is the case of lead. Several observers in France, where there has been a great deal of lead-poisoning in the recent past, and Sir Thomas Oliver in this country, have shown that the influence of this element upon the offspring may be most disastrous. And unfortunately there is more to say than the official records of lead-poisoning reveal.

The Transmission of Lead-Poisoning from Mother to Child

It has long been known that lead has an injurious influence upon ante-natal life, and thus this poison has been taken, and is still largely taken, in all parts of the country, in the form of "lead pills," as an abortifacient—so mortal, in many cases, is its action upon the earliest stages of human life. The time will undoubtedly come when the effective attention of the Legislature will have to be directed against this lamentable practice. Let us now observe how the poison is found to affect the offspring, when introduced into the parental organism, in cases where the father is a house-painter, or where father, or mother, or both, are employed in the making of lead glaze for china and pottery.

The evidence is definite and complete. Observers have been led to notice the frequency of maternal disasters in cases of lead-poisoning. Often the ante-natal period was shortened, and the child was born prematurely, with little chance of survival, or was actually born dead. In less severe cases the influence of the maternal poisoning showed itself in the tendency to epilepsy or "epileptiform convulsions" in the infants, or simply to persistent wasting, or marasmus, as it is called, ending in death probably before the first year of post-natal life was completed.

It may be added that simple chemical analysis, always an easy task in the case of lead, readily showed that the poison entered the second generation from the blood of the first, for the lead can be found in the bodies of babies born dead, or surviving but a few hours, in cases of maternal plumbism. Though plumbism in its ordinary sense has been greatly diminished in this country in recent years, there can be no doubt that the total destruction and deterioration of young life, effected by means of lead and "diachylon" preparations (containing lead) must be enormous.

The Proved Transmission of Lead-Poisoning from Father to Child

The next question is whether paternal plumbism can affect offspring. Here, evidently, is a very different problem. The action of the poison in this case, if any there be, must be upon the paternal germ-plasm, whereas in the case of the maternal organism the poison may act upon the germ-plasm, but also has too abundant opportunities of acting throughout the period of expectant motherhood, by simply poisoning the nourishment of the child through the mother's blood. However, the clinical observers, especially in France, where cases have been so numerous, have settled this important point for us. Paternal plumbism may, and often does, produce racial poisoning by the process of what Forel calls "blastophthoria," or germ-cell-damaging. As we should expect, the lead is much less potent for evil as a racial poison when the father alone has ingested it, than when the mother alone has done so; and the worst prospects for the offspring exist in those cases where both the father and the mother have had lead introduced into their bodies.

Careful observation upon the lower animals has verified the evidence derived

from clinical observation in man. The action of the poison through the paternal as well as the maternal organism has been demonstrated. The reader who desires a complete discussion, with references, of our knowledge of lead poisoning in its industrial aspect, and of the evidence regarding lead as a racial poison, should consult Sir Thomas Oliver's book "Diseases of Occupation," published by Messrs. Methuen.

Primarily, legislation is required, and legislation has already been largely effective in this country. But still better regulation of the use of lead is needed.

The Need for the Abolition of Lead Glaze by the Action of Public Opinion

If public opinion were well enough informed, and conscientious enough, the vested interests would soon find that lead poisoning was not to their interest. Municipalities and corporations should require the use of leadless glaze for their buildings, public conveniences, and so forth. The public should buy leadless ware for domestic use. It is very cheap, and the forms now produced by many makers are often very beautiful.

Only the lack of international agreement prevents us from abolishing the use of lead glaze altogether within a few years, but public opinion can do wonders in this respect. No one who really knew what plumbism is, and what it is liable to do to the next generation, working havoc, above all, in the nervous system of the offspring, would care to buy china the production of which had involved the use of lead glaze, when material as good and useful and beautiful and cheap can be obtained which involves no such possible damage and destruction of the most sacred thing in the world.

It is often argued that there is a necessary and radical opposition between the Eugenist and the social reformer, because the Eugenist wishes to work through heredity, and the social reformer through environment.

Reasons Why Social Reformers and Eugenists Should Co-Operate

The assumed opposition is unreal—except when the Eugenist knows his subject so little as to suppose that nurture does not matter, or the social reformer similarly imagines that good food and education will turn an imbecile into a normal child. But there is no department of eugenics which more clearly provides a meeting-place and common ground for these two points of view than what we here call preventive eugenics. Each of the principal racial poisons that we have to discuss will show how eugenics is needed for social reform, and social reform is needed for eugenics. In the case of lead, we need, for instance, better care taken of our industrial workers and the conditions of industry; and we need, further, a greatly enhanced sense of the importance, for the national life, of the health of mothers, and above all of young married women.

Thus, eugenics and social reform alike demand, in the case of lead poisoning, that married women, at any rate during the maternal stage of their lives, *should not work in lead.* If that demand cannot yet be granted, at least we must demand as much as possible in that direction, especially when we remember that lead is partly excreted from the body of the nursing mother by means of the milk. There should be no chance whatever of the entry of lead in any shape or form into the body of either the expectant or the nursing mother. The valuable maternity provisions of the Insurance Act mark the beginning of due national care of the first of all matters which concern a nation. Under these provisions there will at least be a period of four weeks during which even the mother who works in lead will be unable to ingest any more of the poison.

The Fateful Sapping of Racial Energy by Malaria

We pass now to the racial poisoning produced by certain forms of parasitic disease. If all forms of parasitic disease injured the offspring it can scarcely be imagined that the human race would have survived. In all but a very few instances, we believe that the attack of, say, pneumonia, typhoid fever, measles, practically concerns only the individual [redacted] "germ-plasm," so far as we can [redacted] not affected. All the more [redacted] the exceptions to this rule. Unfortunately, our knowledge is not nearly definite enough in many cases—which include two of the most important of all diseases, malaria and tuberculosis.

As regards malaria, Sir Ronald Ross, Dr. Withington, and especially Mr. W. H. S. Jones, combining their epidemiological with their historical knowledge, have lately argued that the introduction of this disease into Greece may have played the essential part in what was, perhaps, the greatest national tragedy in history—the sudden, cataclysmic downfall of the Greek civilisation. Some evidence

has also been adduced by these students to show that malaria may have also played a part in the decline and fall of the Roman Empire. Sir Ronald Ross believes, judging from the clinical facts of endemic malaria today, that the disease damages the vitality of a race. Its parasite is introduced into the blood in infancy or early childhood, and thereafter its tissues are under the influence of the toxins which the parasites produce. The most characteristic effect of the poison is the sapping of the vital energies. The patient loses his vigour and his "go," cannot stand so much work, has no more initiative.

The Splendid Fabric of Greek Civilisation Undermined by a Parasite

Now, there is evidence to suggest that there was no malaria in the Greece of the great age, and that it was the return of soldiers from wars afar, with malaria parasites in their blood, that led to the spread of the disease in Greece, and the speedy ruin of the most superb and amazing efflorescence in the history of civilisation. Vigorous initiative departed, the race decayed, and a noble civilisation toppled down upon the living foundations which could no longer sustain it. Here we duly record this interesting and remarkable theory, and pass to a disease which more intimately concerns us today.

Tuberculosis involves a chronic blood-poisoning, as malaria does. The possibility of the occurrence of racial posioning in this disease must certainly be considered. Hitherto, Eugenists have concerned themselves with tuberculosis on the simple—too simple—assumption that the disease attacks certain stocks naturally doomed, and can only be got rid of by getting rid of the stocks in question. Elsewhere we have seen that this view, dictated by political rather than by scientific considerations, is entirely unproved and extremely improbable. At least as likely is the possibility that, so far from strengthening a race by its extirpation of the weakest, tuberculosis may turn healthy stocks into weak ones by a process of blastophthoria.

The Arguments Against the Transmission of Tuberculosis from Mother to Child

The biometricians have sought to show, by studying the statistics of tuberculosis, that the disease is inherited. Students of the disease thereupon had to point out that it is an infection, and that the children of tuberculous parents, living in an infected home, would be specially liable to contract the disease. But there is the further possibility that the resistance of the children may be lowered by the influence of the parental tuberculosis upon the germ-plasm from which the children were derived. On this subject, so far, nothing whatever is known; and the factors at work are so many and so intertangled that it would be exceedingly difficult, if not impossible, to ascertain whether this tuberculous blastophthoria does occur. If the tuberculous poison can be shown to be a racial poison, we have another argument against the "better-dead" school of eugenics, who wish to see every destructive agency in full activity, so that a great race may be created.

In the case of maternal tuberculosis, nothing is more remarkable than the fashion in which, very often, an apparently healthy baby is born of a mother who is dying of the disease, whose decline is tragically hastened during her period of expectancy, and who, very often, dies of the disease a few days after the child is born. With the rarest possible exceptions, the child is born uninfected, thanks to the filtering action of the maternal placenta; and often the fair amount of fat on the child's body contrasts with the emaciation of the mother. These facts have to be recognised. But they do not dispose of the possibility that, if a careful and detailed inquiry could be made into the state of the after-history of such infants, we should find, on the whole, that the maternal tuberculosis had prejudiced their future, on the average, even though the infective parasite had been prevented from entering them.

The Discovery of the Parasite Through Which a Terrible Disease is Perpetuated

Here, also, further knowledge is required: but we may be surprised indeed if it does not indicate what our present knowledge indicates—that the way in which to extirpate a disease is to abolish the disease agent, instead of letting it abolish us.

As regards the action of syphilis upon the race, there is, unfortunately, no question whatever. Such dispute as there is here concerns only the question of our duty —which is itself disputed—and of the ways and means of performing it. The disease is due to a minute animal parasite, extremely slender and transparent, which, from its physical appearance, is called the *spirochæte pallida*. Only some half-dozen years have passed since its discovery by the brilliant young German parasitologist Schaudinn, whose untimely death, soon thereafter, was a great loss to science. Its extreme slenderness and paleness, together

with its lack of chemical response to the stains or dyes which ordinary microbes take up, and are therefore made visible by, explain the fact that for nearly four decades this parasite baffled the best efforts of the most skilled observers to detect it. But it can elude us no longer, and already the fruits of poor Schaudinn's discovery have been rich.

Like many other of the more important disease parasites, especially those of animal type, this cannot be cultivated outside the body. Nevertheless, much can be done in the way of observing the action of drugs upon the parasite, once we can identify it.

Searchers for Poisons to Kill the Hideous Parasite

Here we are specially indebted to Professor Metchnikoff, of Paris, and Professor Ehrlich, of Frankfurt. The Russian scientist, working at the Pasteur Institute, was able to prove that the use of certain preparations of mercury would kill the parasites in an infected spot—say, a surgeon's finger, not infrequently attacked in the course of operating, or examining an infected baby—and so arrest the disease before any of its manifestations appeared. In Frankfurt, at a later date, Professor Ehrlich was able to go further still. The clue he followed was derived from the observations of the parasitologists. In their study of the form and zoological type of the pallid spirochæte, they used a number of reagents or stains in order to bring out its details of structure, which are few enough. Ehrlich argued that the kind of reagent which stained the parasite best would be the kind that had the most affinity for its tissues. This reagent might not itself be lethal, or even toxic, to the parasite; but if it were possible to construct a chemical compound whose constitution comprised some poisonous substance—for instance, arsenic—and also the reagent which the parasite took up, then the reagent might act as a kind of link or introducer between the tissues of the parasite and the poisonous drug which we desire to act upon them.

A Success in Curative Medicine that Approaches if it is Not Here

For some decades past, Ehrlich has been working at the chemistry of such problems. When the spirochæte of syphilis was discovered, he brought his experience to bear upon this new one. A long succession of compounds was tried, in the hope of finding one that should be "fixed" by, and should thus kill, all the spirochætes in the body and blood of a human patient. The six hundred and sixth compound experimented with, now known everywhere as "606," or salvarsan ("saving arsenic"), proved itself invaluable. The controversy regarding it is not yet settled; questions of "patriotism" have complicated it, the general rule being that observers on one side of the Franco-German frontier find salvarsan priceless, and those on the other side find it dangerous and deceptive. Here, where the war of 1870-71 does not seem relevant to the merits of a drug in a disease to which French and Germans and all other kinds of human beings are liable, we have already found that salvarsan is a most valuable remedy for syphilis.

The discoverer's hope was that a single dose of the drug might effect the complete destruction of every syphilitic parasite in the body, and so *cure* the patient then and there. That hope is perhaps too hopeful; but the time may be very near when the disease can thus be cured outright and, for practical purposes, instantaneously. Salvarsan has been notably successful in the case of syphilitic infants. And the evident reason why it has been necessary for us to discuss this therapeutic subject in this section is that, if and when syphilis can everywhere be cured in twenty-four hours or so, with the result that the patient is no longer infectious, having no living parasites in his body, the Eugenist need concern himself about this disease no longer.

The Cruel Doctrine that Disease is a Scourge of Sin

The words of Whittier will have received yet another justification when, addressing the Earth, he said:

> But, one by one, the friends of ancient wrong
> Go out, and leave thee free.

Probably the hour is very near. Meanwhile, in order, above all, that public opinion may avail to use the new knowledge when it is in our hands, the Eugenist is required to state the facts. This is an intensely active infection. It effects a racial poisoning in the most certain fashion possible, for the poisonous agent enters the offspring, as we saw in the case of lead; and, further, it multiplies there, and may be passed on to others by contagion—as lead cannot. Owing to the fact that, in many cases, this disease is associated with what we call "vice" (as if there were no other vices, with their own appropriate diseases appended thereto), there are, or were until very lately, many people who deprecated any attempt to cure or prevent it. According to their diabolical creed, this was the divinely appointed

scourge of sin, with which man must not presume to interfere.

Of the many answers to this proposition, one at least may here be cited: it is that the disease very often attacks the innocent. The unknowing, guiltless infant, the unknowing, loving, faithful wife, the devoted and conscientious nurse, the midwife, the surgeon, the man who accepts the loan of a friend's pipe, the little girl who takes a glass of milk at a railway-station—all these and many more may be infected, and may pass on the parasite to others. The infection, thus contracted, may appear, after a time, to be cured; but, twenty or forty years later, the symptoms of locomotor ataxia or of general paralysis of the insane may appear, as the remote and mysterious but proven consequences of it. If under the sun, of today or any past age, there is or ever has been an entirely abominable creed and practice, which it is the duty of all honourable and humane people to denounce as a hideous lie, it is that which declares that man is immoral and a champion of immorality when he seeks to kill and confine the microscopic enemy of his race which is called the *spirochæte pallida*.

The Necessity of Notifying All Cases of Disease Dangerous to the Community

Very different is the demand here made, in the interests of individuals and the race, that this disease shall henceforth be notified, in all classes, just as we now notify typhoid fever, measles, or whooping cough.

The public has already come to realise the propriety of notifying tuberculosis. No one would now venture to go back upon that piece of simple, common sense. But while we notify tuberculosis, and many other diseases which, except in a few cases, are of very little practical importance, we do not notify the two most terrible infections that we have with us. While we deplore the falling birth-rate we are silent about the preventable causes which make any birth-rate impossible in hosts of instances, and blind those born in many more. Here are racial poisons of the completest possible kind, for their action in many instances is to put an end to the race altogether, so far as their victims are concerned. And they crowd the waiting-rooms and fill the waiting-lists of all the women's hospitals in the country.

The Insurance Act will make things easier. Responsible people will see that we cannot award sickness benefit and medical benefit without stint in such cases, and the necessity of notification will become apparent. But it must be clear from the first that this demand is made in the interests of no class, nor with the object of oppressing any class. The object is to stamp out disease; and therefore, just as if the disease in question were typhus or cholera, the notification must apply to all cases wherever and whenever they occur. The conditions of infection are such in the case of these diseases that proper measures taken against them, as against, say, typhoid, would be far more quickly and certainly successful in abolishing them altogether.

A Call for the Education of Adolescence in the Most Important Facts of Life

The object of notification is what the object of medical inspection was supposed to be by those who spent years in advocating it—*treatment*. We want to know where the cases are, in order to treat them, *at once*, with the best means known to medical science. There will then soon be no more cases to treat or to notify.

Only one other measure do the principles and ideals of Protective or Preventive Eugenics demand in this connection. It has already been referred to in a much earlier chapter. It is the education, and also the instruction—a lesser but indispensable thing—of adolescence in regard to these terribly important facts of life as we have to face it today. If the four agencies, whose duty it is, could only be got to confer and unite, the task would be done. Those agencies are the parents, the teachers, the clergy, and the doctors. They should meet, without prejudice, without professional jealousy, and should discover the best means of fulfilling the great duty which is imposed upon all of them, and which, at present, they all systematically and heartily neglect, with the exception of rare, brave individuals here and there.

The Doom of the Doctor and the Rise of the Teacher

Given such education for parenthood, together with such scientific and medical instruction as is required, and as the Germans are already beginning to give their young people, and the doom of these diseases will be at hand. The day of doctoring for doctors will come, the word "doctor" meaning "teacher"; and when drugging of the mediæval type is abandoned for this real doctoring, and when men and women doctors are employed to instruct youth of both sexes in these matters, which so intimately concern them and the race to come, it will be a happier and sweeter and cleaner race than it was in our time.

PROBLEMS OF STAR-LAND

Star Colour and Colour Changes—Increase and Subsidence of Brightness—Unexplained Comings and Goings

WHAT DARK STARS RANGE THE SKY UNSEEN

EVEN to the unaided eye, many of the stars display beautiful tinges of colour, and especially of red. But these colours are enormously increased in splendour and beauty by the telescope, which also reveals the delicate tints of many stars that otherwise appear white. The most deeply coloured of all first-magnitude stars is Antares, which is of a wonderful ruby red. Successively somewhat less deep and rich in tone, though of the same colour, are Betelgeux, Aldebaran, and Arcturus. Ptolemy includes in his list of fiery red stars, besides the four we have mentioned, Pollux and Sirius, neither of which could now be classed as red. The light of Pollux is indeed inclined to yellow, but Sirius, as we have seen, is of a cold, dazzling, bluish-white. Have these stars, then, changed in colour ?

Some authorities have disputed the genuineness of Ptolemy's inclusion of Sirius in his list, and maintain that the name has crept into the text by the error of a copyist. There is a good deal to be said for this view, for a later writer mentions five as the number of red stars catalogued by Ptolemy. But the imputation of colour to the Dog Star seems to be of wider occurrence in ancient literature than justifies us in rejecting it as altogether baseless ; among others, Homer, Seneca, Cicero, and Horace refer to it as red, and the impression of its fiery glare seems to have been general. No one could now call Sirius a red star ; nor does it seem likely that its red colour persisted beyond the early centuries of our era, for in all the many works of Arabian astronomers of the tenth and later centuries there is no suggestion that the star was at that time coloured. It is, on the whole, likely, then, that we have here an example of real colour change, and that Sirius actually had, in ancient times, a ruddy and lurid appearance which he has since utterly lost.

This is the more probable because there are other examples of colour change which appear to be duly authenticated ; yet it must always be a difficult matter to determine these alterations of tint until some scientific means has been discovered for registering and comparing the colours of stars. Innumerable difficulties have, so far, beset any attempt to record these colours with any certainty, because no two observers can be sure that they see colours exactly alike, and even the two eyes of one individual may perceive different colourings in the same object. Again, it has often been found that different people use various terms to describe the same colour, and intend different colours by their use of the same term. So it is that differences in instruments, in atmospheric conditions, and in all kinds of personal factors make it impossible to eliminate, at the present stage of science, a large amount of error and of subjective disagreement.

Yet some examples of colour change seem, as we have said, to be sufficiently attested. Algol, the Demon Star, in the constellation of Perseus, is noted by Al Sufi, the Persian astronomer, as a red star, but is now pure white. It may be that Algol, which is a celebrated variable star, assumes at times a temporarily red hue ; for in modern times the astronomer Schmidt saw it once, in 1841, of a yellowish-red colour, but on all later occasions he found it white. Other cases are on record, of which T. Ursæ Majoris and S. Cephei are among the best known. All of them change between red and white, and it is in red stars alone that this tendency to vary in colour is found, just as it is in red or reddish stars that variations in magnitude are chiefly found.

Much more beautiful and impressive, however, though only visible by means of the telescope, are the pairs of coloured stars

which are by no means uncommon in the heavens. Stars which to unaided vision seem but a single point of more or less doubtful colour reveal themselves in the telescope as pairs of stars, displaying amazingly lovely harmonies of colour, either contrasted or graded. Moreover, real changes of colour seem also to be fairly common in these pairs. A very beautiful pair, known as 95 Herculis, have been seen by many observers in contrasted tints of green and red—"apple-green and cherry-red"; but there are also authentic records of their having been seen, on various occasions, respectively green and yellow, gold and azure, bluish-white and reddish, greenish-yellow and reddish-yellow, and again both white, while at present they are both of a delicate primrose tint.

Instances of Companion Pairs of Stars that Tone Beautifully in Colour

Colour changes of this nature may occur in equal pairs, or in unequal pairs consisting of a primary and a satellite; in the latter case the satellite frequently varies, while the primary remains constant in colour. But the contrary never occurs; there is no case of a primary subject to change in colour while its satellite remains constant.

Beautiful instances of coloured pairs are found in a star in Andromeda, where one of the pair is orange and the other green; a star in Cassiopeia, one yellow and the other rose-colour; in Cepheus, with one orange and one purple; another pair in the same constellation, gold and azure respectively; a pair in Cygnus, similar to the last; Delphinus has a pair, yellow and emerald; Draco includes another, of which one member is orange and the other emerald; a wonderful pair in Serpens are sea-green and lilac respectively; Virgo has a coloured pair, of which one is light rose and the other dull red; and other various examples might be given. Very delicately lovely effects are produced by the not uncommon juxtaposition of a bright white star with a small blue or lilac star. Rigel and Regulus, brilliant white stars, have attendants of azure, indigo, lilac, or amethyst shades.

Stars that Vary, Some Regularly, Some Irregularly, in Brilliancy

It has been noted that stars which vary in colour are usually subject to changes in magnitude. These changes in brilliancy are more open to exact observation than the changes in colour, and some knowledge has already been obtained of the nature of their causes. More than four thousand stars of unquestioned variability are now known; some of them vary in no definite periods, but altogether irregularly; others vary in regular periods, the shortest known period being three hours and twelve minutes, and the longest being six hundred and ten days.

Stars with regular periodic fluctuations in magnitude range themselves into two quite distinct classes, according to whether the periods of change are long or short. Long-period variables have periods usually between one hundred and fifty and four hundred and fifty days, though the period may in this class be as short as one hundred and twenty days or as long as six hundred and ten. Short-period variables, on the other hand, have periods of less than fifty, and, indeed, usually less than ten days. There are a few stars with periods intermediate between those of the two classes, which form gradations between them; but the two classes are physically distinct, and their variations are due to different causes.

The most famous of the long-period variables is Mira, or "the wonderful," in the constellation Cetus. It was first noticed by David Fabricius, a Frisian pastor, in 1596, but was then taken for a "nova."

The "Wonderful" Star that Varies Between the First and Tenth Magnitudes

Its true character was not discovered until 1639, by John Holwarda, a Dutch professor of philosophy; and in 1667 Bouillau assigned to it a period of three hundred and thirty-three days. But its periods are subject to considerable irregularity, so that neither the maximum nor the minimum brilliancy can be determined beforehand with any precision. Either may be hastened or retarded by a week or two, and occasionally as much as forty days, from its appropriate time; and there seems to be no order or rhythm in the occurrence of these digressions. Neither is there any regularity in the intensity of the light-variations. The maximum brightness has been known to attain nearly to the first magnitude, for Sir W. Herschel noted Mira in 1779 as almost equal in brilliancy to Aldebaran, a standard first-magnitude star; but at other times it fails even to attain, at its greatest brightness, to the fifth magnitude. Its minimum, though on the whole more uniform, is also subject to irregularity; it usually falls to between the ninth and tenth magnitudes, but has been known to descend considerably lower than this. In 1783, for instance, Sir W. Herschel could find no trace of it with a telescope in which all stars down to the tenth magnitude were visible. If we consider the whole range

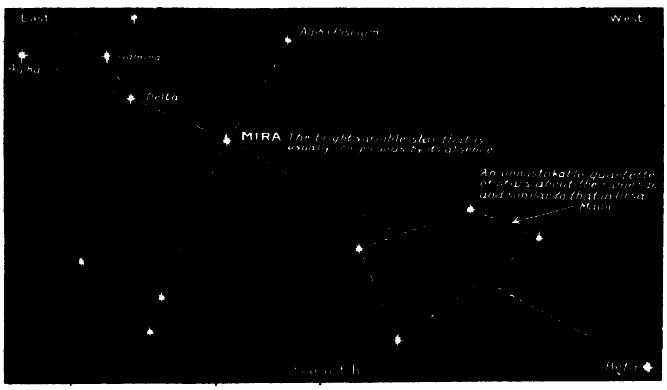
within which the brilliancy of Mira has been recorded to vary, we find that the light emitted by it at certain periods is fifteen hundred times as much as the light emitted at other periods.

The occurrence of these variations in brilliancy pursues a course more or less as follows. At intervals of about eleven months the star begins to brighten, and rises from below the ninth magnitude to a maximum which varies, as we have seen, but often reaches the second magnitude. This is accomplished in about one hundred and ten days, and the star then remains for two or three weeks in the glory it has attained; it then subsides to its former low estate, taking about twice as long in the descent as in the ascent. In point of fact, this star is perpetually in process of change; but for ordinary observation it may be said to remain at a high level of brilliancy for about two months, and at a low level of brilliancy for about three months.

Another famous long-period variable in the constellation Cygnus shines at its maximum with more than six thousand times its minimum brilliancy, rising and falling in periods of four hundred and six days between the thirteenth and the fourth magnitudes. The period of this star, which is of a beautiful scarlet colour, has lengthened with fair regularity by about a quarter of an hour each time since its first recognition, in 1686.

These two stars show exceptionally long ranges of fluctuation, for the average amount of variation in seventy-five long-period variables which have been kept under close observation at Harvard has been found to be five magnitudes.

Spectroscopic examination has shown that these fluctuations in light are accompanied by definite physical changes. The outburst of brilliancy is caused by a periodical conflagration in the variable star. Further, the curves of the variation of light in long-period variables are found to be closely similar to the curve of the frequency of sunspots in our sun. The physical causes of the two phenomena are almost certainly of the same kind, though their apparent results are so different. The points of similarity in the curves of sunspot frequency and of the variation of light in a star such as Mira are noteworthy. In both, the rise is much more rapid than the fall; and both show a check in the descent, with an attempt at a second maximum, thus giving the curve the appearance of a double peak, of which one point is considerably higher than the other. These variable stars at their greatest brightness show bright lines in their spectra, indicating blazing gases; and we know that the corona of the sun emits a greatly intensified light at the periods when sunspots are most frequent. It is true that no variable star has yet been discovered with a period corresponding in length to that of the frequency of sunspots, but this, again, is only a difference of degree and not of kind. The two phenomena are certainly closely related, and any discoveries in connection with the occurrence of sunspots may prove to shed considerable light on the nature of the fluctuations in long-period variables.



MIRA, THE LONG-PERIOD VARIABLE STAR IN CETUS

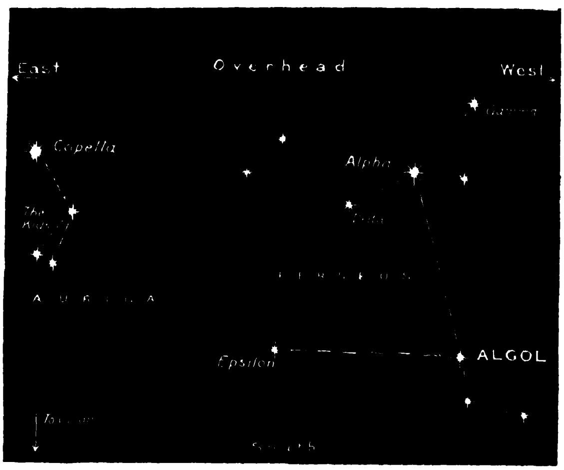
Mira will be found by this diagram of the larger stars, in the south from 9 p.m. to 10 p.m. in October and November, and an hour or so earlier in December.

Stars of this class are almost all red, and show bright lines of hydrogen in their spectra. In addition to those which we have already named, the following deserve special notice. R. Hydræ is a variable with a period which grows shorter at each recurrence, so that from five hundred days in 1708 it had become four hundred and twenty-five days in 1891—a red star which rises nearly to the third magnitude. S. Ursæ Majoris, recognised as a variable in 1853, has a period which is gradually lengthening by a succession of irregularities of all sorts, but which may be reckoned at about two hundred and twenty-nine days. This star is deep red in its lower phases, but at its maxima sometimes becomes almost white. T. Ursæ Majoris, a dull red star with a period of about three hundred and two days, is also subject to irregularities

of many kinds. R. Leonis, a beautiful star of glowing red, varying at its longest ranges from the fifth to the tenth magnitude, has a period which is gradually shortening, but is too complicated for exact estimation; it is somewhat less than three hundred days.

The star with the longest known period of fluctuation is in the constellation of Auriga, and completes its changes in six hundred and one days. The whole extent of its variation covers less than one magnitude, and the increase and decrease of light take place so slowly as often to pass unobserved. The star is a binary system; but its changes in luminosity, though probably not unaffected by this fact, are not produced by eclipses, for the calculated movements of the component stars do not admit the possibility of eclipse.

The process of change in the short-period variable stars is in many ways quite distinct from that of long-period variables. In the first place, the fluctuations in the short-period stars are perfectly regular, rising and falling in orderly rhythm; and, in the second place, the changes are of much smaller range, the total variability rarely extending over more than two magnitudes. It is almost certain that the variations in light of all stars of this class are due to the fact that each of these stars consists of two bodies revolving round one another; and the various groups into which they may be divided represent the different natures and relations of the individual stars in each binary system. Four stars may be taken as types of the groups: Algol, Beta Lyræ, Zeta Geminorum, and Delta Cephei.



ALGOL, A SHORT-PERIOD VARIABLE STAR

Algol is nearly overhead in November, December, and January, and towards the N.E. before and the N.W. after these dates

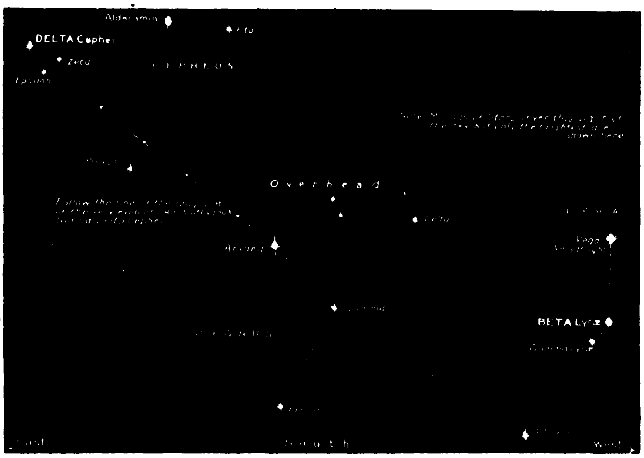
Algol variables, or "eclipsing stars," are marked by periods of precise regularity. The light is constant during the greater part of the time, but at regular intervals suffers a certain unvarying diminution. It is at once clear that these changes represent a periodical eclipse of the luminary by a companion passing between it and us, in the course of a regular orbital motion. Such systems are of very great interest, because they are open to a considerable amount of investigation. Thus, if there are two equal and equally luminous bodies, there will be two equal minima, or eclipses, in each period; but if one of the two equal bodies is dark, as in the case of Algol, there will be only one eclipse in the period. We can tell by spectroscopic examination whether a period includes one eclipse or two equal eclipses, for the spectroscope reveals the direction of motion of the luminaries. If, again, there are two unequal bodies, or two bodies of unequal luminosity, this will be shown by the occurrence of two unequal minima in each period. Where there is one small bright star and another large but only slightly luminous star, we get a prolonged and low minimum brightness, the occulation of the darker by the brighter star being hardly marked by any change in brilliancy.

It is obvious that these short-period variable stars are not distinguished by any physical peculiarities from other binary systems of stars; their eclipses, or regular variations in light, are due only to the fact that their motion around one another takes place in the plane of our vision, and are determined by our position in space relatively to the movements of these stars.

Algol, the model star of this class, was probably known as a variable in ancient days; so, at least, we may judge from its name, which signifies "the demon," suggesting some preternatural fire or spirit observed in its shining. The nature of its fluctuations was discovered in modern times by John Goodricke, a deaf-mute of York, in 1783, who also suggested the true explanation of these changes. Since that time Algol has been observed with great care, and much has been learned of his system. This consists of a light and a dark body. The primary star is a brilliant sun of the helium type, and around it revolves a huge planetary body, practically without luminosity. The primary star is just over one

million miles in diameter—that is to say, once and a quarter the diameter of our sun. The size of the satellite is not so easy to compute with accuracy, because its centre does not pass exactly across the centre of the primary; but Professor Vogel estimates its diameter at eight hundred and thirty thousand miles, and this is probably not far from the truth. It is calculated that the distance from centre to centre of these two enormous globes is probably not more than three and a quarter million miles, so that their surfaces are within less than two and a half million miles of one another. Such close proximity of these two vast bodies seems almost incredible in view of the stability with which they are known to retain their relative positions and motions. But this near neighbourhood is apparently not uncommon in stellar systems; we find huge luminaries retaining their mutual relations unimpared for ages in even closer proximity than this.

Variable stars of the type of Beta Lyræ have no interval of constant luminosity within their period; they present a continuous and perfectly rhythmical series of fluctuations. The light-curve shows two equal maxima, separated by two unequal minima.



VARIABLE STARS—BETA LYRÆ AND DELTA CEPHEI

These stars are almost overhead in summer and autumn, and towards the west overhead after October. To identify them, face south with diagram and look up.

The two other types of short-period variables—those which follow respectively Zeta Geminorum and Delta Cephei—are in constant process of light-variation, but differ in respect of the details of the process. In the Geminid stars, as they are called, there are two equal maxima and two equal minima of brilliancy; but in Cepheid stars the variation in brightness is very unsymmetrical, though it is accomplished with the same regularity of period as in the other cases. Delta Cephei is a very strange star which deserves closer attention. Its total period from minimum to minimum occupies nearly five and a half days, and the light varies during this time from the magnitude of 4·9 to that of 3·7, and down again. It takes, however, only one and a half days to accomplish its rise, the descent occupying the remaining four days. But this descent is not accomplished with the smooth regularity which marks the rise. About fifteen hours after the turn there is a halt in the descent, and the star remains stationary in brilliancy for a short time before resuming its declining course. The curve of light-change is, in fact, very like the curve of sunspot frequency and of long-period variables. But it has been proved by means of the spectroscope that stars of this group, as well as Algol variables, are indeed binary systems, and that they have periods of mutual revolution corresponding with the periods of their fluctuations in light. It is known, however, by the same means that the light-minima in the Cepheid variables do not represent eclipses or occultations. Some other explanation has therefore to be sought.

The theory put forward by Mr. Myers seems to offer a possible solution of the several features of light-variation in these non-eclipsing short-period, variable stars. Since the changes never cease, and the light can never be regarded as stable, it seems that the two component stars must be always affecting one another, and consequently that they must be nearly or actually in contact. In a system so close as this, tidal forces will necessarily have enormous effect, and the stars will consequently not have a spherical form, but will be considerably drawn out in the direction of a line joining their centres. They will, in fact, be spheroidal or egg-shaped. Therefore, when the two bodies are broadside on, we get a maximum of light, and when they are end on we get a minimum. If one body should happen to eclipse the other, the minimum will be intensified, but the gradual turning of the spheroids will soften the changes and prevent any abruptness.

A remarkable smoothness in the curve

of variation does, in fact, characterise these variables. It is obvious that two equal maxima are presented to us in a revolution such as that described above, for the line of centres will be twice at right angles to the line of vision, the stars being then broadside on to us. If the two components in such a system are of unequal brilliancy, we get two unequal minima, according to whether the brighter or the duller star is nearer to us. In this way we might get a light-curve resembling that of Beta Lyræ. If the two components of such a system are of equal brilliancy, we get a regular curve of light-change with equal minima as well as maxima, a continuous wave of ups and downs as in Zeta Geminorum, which varies with complete symmetry in a period of about ten days. The extremely unsymmetrical light-changes of Cepheid stars would, on this hypothesis, be due to a large eccentricity in the motion of the two bodies thus in contact with each other.

Changes of Brilliancy in Members of Star-Clusters

This explanation is, as has been said, so far purely hypothetical, and there are great difficulties in the way of accepting it fully. For one thing, stars in such relations with one another must necessarily be of extreme tenuity, yet many of them are of considerable brilliance. There are also notable changes in the spectra which find no explanation under this view. It seems likely, however, that the real solution will be found in some combination of tidal and orbital effects, and the hypothesis given above has many evidences of truth. But it can hardly be the whole explanation.

Certain star-clusters contain a large proportion of variable stars. Thus, out of nine hundred stars examined in one cluster from Harvard, one hundred and eighty-five were found to be variable. The variation in the case of cluster-stars seems to be marked by special features of its own. The periods are remarkably short, averaging about twelve hours in the cluster mentioned above. The variation is not continuous, as in the stars which we have just been considering, but the light remains at minimum for the greater part of the period, then springs up with great rapidity to maximum, falling back more slowly to its former low level. Eclipses cannot conceivably be the cause of this kind of light-variation; not a sudden failure in light, but a sudden access is here apparent. Possibly these cluster variables have some sort of affinity with the "novæ" or temporary stars.

Of all changes of brilliancy in stars, the "novæ" or "new" stars are the most striking and astonishing examples. Rising in an incredibly short time out of total invisibility, they have been known to blaze out in the heavens with a brightness exceeding that of any other star, and to maintain this regal splendour for months together, afterwards fading away into oblivion or into a wan and spectral state of existence bearing no semblance of their short-lived glory.

Some Famous Examples of Brilliancy and Decline in Stars

In a minor degree such accessions of brilliancy, single and unaccountable, are not uncommon, but we need only notice the famous examples. Instances of such phenomena are on record from early times, and most of them were apparently genuine new stars. Among them are those of 134 B.C. in Scorpio, known as the star of Hipparchus; 123 A.D. in Ophiuchus; 173 A.D. in Centaurus, visible for eight months; 386 A.D. in Sagittarius; 389 in Aquila, rivalled Venus in brilliancy, but vanished in three weeks; 393 and 827, both in Scorpio; 1012 in Aries; 1203 in Scorpio; 1230 in Ophiuchus; 1572 Tycho's star in Cassiopeia; 1604 Kepler's star in Ophiuchus; 1670 in Vulpecula. With the nineteenth century, and especially since the application of photography to astronomical research, they become more numerous. Probably the most famous new star of recent years was Nova Persei, discovered by Dr. Anderson, of Edinburgh, in February, 1901, which in two days became the brightest star in the northern heavens, and then gradually decreased in brightness until after two years it had declined to the twelfth magnitude, at which it then remained constant.

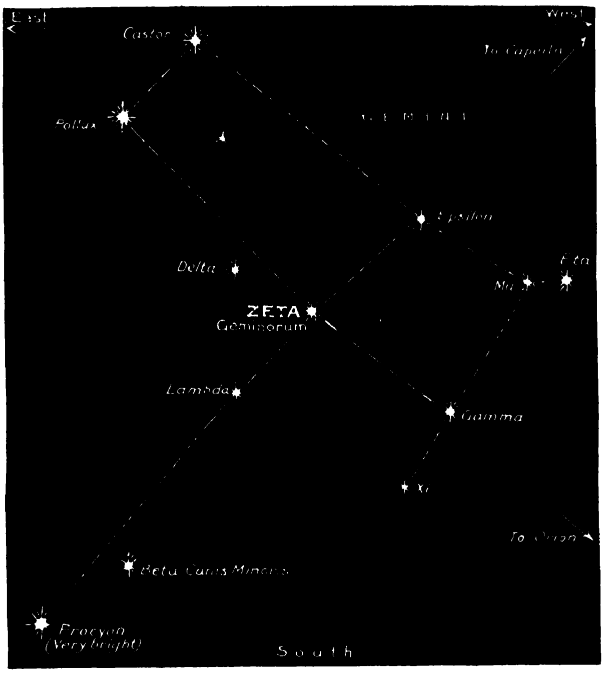
The Radiantly Brilliant New Star which Tycho Brahe Discovered

It will at once be noticed that special regions of the sky alone seem to produce new stars, and almost all the positions in which they have been observed lie in the Milky Way. The most famous of all these apparitions is that known as "Tycho's star," in Cassiopeia. It was carefully observed by Tycho Brahe throughout its course. He noticed it as a "stranger star" on November 11, 1572, though it had been seen by other observers two or three days previously. At first of a radiantly

white colour, it shone in magnificent splendour, passing from equality with Jupiter to a brilliance surpassing even Venus. It was so bright that it could be seen on cloudy nights when no other star was visible, and some observers discovered it even in the full light of noon. But its splendour was short-lived. After about three weeks of this pre-eminence it began to fade, shone redly, but still noticeably for some time longer; then became dimmer, so that from May, 1573, its colour was "pale with a livid cast," and in March, 1574, it disappeared. Even now it has not passed into utter darkness, but lingers on, a feeble eleventh-magnitude shadow of its former self. The history of most novæ is more or less similar to this.

Little is so far known, or even conjectured with any assurance, as to the nature of these brief and sudden outbursts of brilliant luminosity. The suggestion which is made by Miss Agnes Clerke is probably as safe as any. It is to the effect that "stars in the Milky Way occasionally get entangled in the diffuse nebulosities with which that region abounds, and blaze through the resistance offered to their motion, just as meteors kindle to brief splendour in shooting athwart our cloud of circumfluous air."

It is impossible with our present knowledge, however, to apply this general explanation in any detail. Yet it seems to light up for a moment one very attractive realm. Mr. Halm has elaborated an ingenious theory of the phenomenon, describing the genesis of a new star's visible career as the moment when "a dark body impinges upon and penetrates into a mass of nebular material." It is the kingdom and being of these dark bodies that at once allure, evade, and satisfy us. Stars we can never see, motions we can never measure, relations which remain for ever profoundly concealed, are yet now and again for a moment disclosed. We learn from the new stars that this vast, dark realm exists. Indeed, the existence of dark stars is made known to us in three ways. First, as members of binary systems consisting of a bright and a dark star, we become aware of the dark stars when they occult their luminous companions; secondly, also in binary systems, the presence of dark stars may be discovered by periodic changes in the velocity of luminous stars, as determined by the spectroscope; and, thirdly, dark stars are known to exercise perturbing influences on stars which are visually double and whose orbital movements have been observed.



ZETA GEMINORUM, A SHORT-PERIOD VARIABLE

This star will be found almost overhead, towards the south, in January and February, towards the east in December, and towards the west in March.

In all cases where they are noticed, dark stars must be members of systems containing bright stars also, for it is by their effect on these that we know them. But it seems probable that in novæ, or temporary stars, we have examples of dark stars which actually become visible on their own account. From all these instances we are bound to conclude that the number of dark bodies pursuing their motions in space is very great indeed. It is impossible to regard these dark bodies merely as expired luminaries. Some may be stars which once were bright and are now extinct, but there must be many others in which darkness is not a sign of decrepitude, but is rather a constitutional feature, or perhaps lack of some feature necessary to the production of luminosity. It is even possible that dark stars form the majority of heavenly bodies, and that space is tenanted by a host of undiscoverable star-systems far outnumbering the myriads of luminaries which powerful telescopes are revealing.

THE GREAT AFRICAN RIVAL OF NIAGARA

THE VICTORIA FALLS OF THE RIVER ZAMBESI, RHODESIA—A DROP OF FOUR HUNDRED FEET

This photograph is by courtesy of the British South Africa Company; others on these pages are by the New Zealand Government Messrs. Underwood & Underwood Frith, and Photochrom.

THE GREAT RIVER PLUNGES

How the Waters Come Down at Niagara, Victoria, and Kaieteur

THE WONDER OF STUPENDOUS CATARACTS

Few phenomena of Nature are more impressive than waterfalls, few more comprehensive and manifold in their appeals to the imagination. Some are "like a downward smoke, slow-dropping veils of thinnest lawn;" some plunge in foam over terrible precipices; some race downward to the sea, cascade after cascade, cataract after cataract, but all are things of beauty, and many are things of majesty.

To all appearance waterfalls are the result of greater or smaller precipices down which streams and rivers are compelled to plunge, but, as a matter of fact, the rivers and streams have themselves cut out the steps and precipices down which they leap. Originally, in most cases, the river or stream runs at ordinary gradients down ordinary declivities; but, owing to the nature of the rocks over which it runs, it corrodes some parts of its bed rapidly, and some parts slowly, and where it meets a hard ledge of rock succeeded by softer rock it gradually eats away the softer rock beyond the ledge, and leaps over the ledge as a waterfall. In the case of Niagara, the river leaps over a ledge of hard limestone, which it has failed to erode, into deep gorges and chasms it has cut in soft shale.

The greatest falls in Europe, the Falls of the Rhine below Schaffhausen, are also over hard limestone ledges. The Ashgill Force Fall, in England, and the cataracts of the Nile are likewise due to limestone rocks that resist erosion. Most of the Swiss waterfalls leap over ledges of limestone, gneiss, and granite. The great fall of the Missouri, on the other hand, falls over a ledge of Triassic rock on to softer Jurassic strata, and the great Kaieteur Fall, in British Guiana, a fall 822 feet high, is over a ledge of hard conglomerate sandstone, on to beds of softer sandstone.

Of course, however hard the ledge may be, it is gradually worn away. Not only so, but the river as it falls over its ledge naturally undermines any softer rock underlying it, and the unsupported ledge breaks off bit by bit. In this way, by the undermining and breaking away of the ledge over which they fall, the American Falls of Niagara have receded 30 feet, and the Canadian or Horseshoe Falls 104 feet, and in some places 270 feet, in the last forty-eight years; while the Falls of St. Anthony, on the Mississippi, receded at an average rate of 5·15 feet per year during the years from 1680 to 1856. The ultimate result of such cutting back is obviously to destroy the ledge of rock which makes the waterfall, and, in time, every river must destroy its own waterfalls.

But waterfalls are not always due to these incorrigible ledges. In some cases they are due to faults in the rocks—that is to say, to precipices produced by fracture and displacement of layers of rock. Thus, the Glen Falls, on the Hudson, are made by the displacement of layers of sandstone rock; and the Yosemite Falls, which take 1500 feet at one leap, are due to a similar displacement. In other cases waterfalls leap down great fissures rent in the earth's crust by earthquakes and other violent convulsions. The most notable example of a fall of this kind is the Victoria Falls of the Zambesi, which plunge down a great rent in the hard basaltic rock that forms the bed of the river. Another waterfall of this nature is seen in the Dettifoss Fall, in Iceland, which plunges vertically down 350 feet into a volcanic fissure some twelve miles long. In still other cases falls are produced by an accumulation of boulders which block up the bed of a river. The Coles Falls on the Sturgeon River, for instance, leap over a great dam built up of boulders of limestone, gneiss, and granite.

The best-known and most famous of all falls is, of course, the Niagara Falls of the Niagara River. The first to describe the falls as an eye-witness was Father Hennepin, who visited them in the winter of 1678-9.

HOWICK FALLS, NATAL

He made a sketch of the Falls, and wrote: "Betwixt the Lakes Ontario and Erie there is a vast and prodigious cadence of water, which falls down in a surprising and astonishing manner, insomuch that the universe does not afford its parallel. 'Tis true that Italy and Swedeland boast of some such things, but we may well say they are sorry patterns when compared with this of which we now speak . . . It (the river) is so rapid above the descent that it violently hurries down the wild beasts while endeavouring to pass it to feed on the other side, they not being able to withstand the force of its current, which inevitably casts them headlong above six hundred feet high. This wonderful downfall is composed of two great streams of water and two falls, with an isle sloping along the middle of it. The waters which fall from this horrible precipice do foam and boil after the most hideous manner imaginable, making an outrageous noise more terrible than that of thunder, for when the wind blows out of the south their dismal roaring may be heard more than fifteen leagues off.

"The River Niagara, having thrown itself down this incredible precipice, continues its impetuous course for two leagues together to the great rock above mentioned with inexpressible rapidity. . . From the great Fall unto this rock, which is to the west of the river, the two brinks of it are so prodigiously high that it would make one tremble to look steadily upon the water rolling along with a rapidity not to be imagined."

Allowing for considerable exaggeration, Father Hennepin's description of the Falls is not so very inaccurate. The actual dimensions of the Niagara Falls as now known are as follows. The American Fall has a width of 1060 feet; the curve of the Canadian or Horseshoe measure 3010 feet; and the Goat Island, which stands between these two sheets of falling water, has a frontage of 1300 feet. The distance from bank to bank, therefore, is about a mile. The height of the American Fall is 162 feet, and of the Horseshoe Fall 155 feet.

It is apparent that the height of the Falls is small in comparison with its width, and the effect of this is to make the Falls appear like a low, long wall, an effect that is apt to disappoint those who see the Falls for the first time. In height, indeed, the Niagara Falls are surpassed by many other falls, but not upon its height but upon the enormous volume of water does its impressiveness depend. An ordinary river a few hundred yards wide falling over a precipice 150 feet high would be magnificent and impressive, but the Niagara is more than an ordinary river; it is almost a mile wide

and every second about 200,000 cubic feet of water, weighing about 8000 tons, pour over the limestone ledge. The force represented by this falling water is equivalent to millions of horse-power, and perhaps nowhere else in Nature is such enormous power so picturesquely manifested. Day after day, hour after hour, century after century, these white waters leap over the abyss.

Every year about a million people visit the Falls, and many famous writers have recorded their impressions. A book might be filled with interesting descriptions of the Falls by interesting people. It must suffice here to give descriptions by Anthony Trollope and Edwin Arnold.

Trollope writes : " It is glorious to watch the waters in their curve over the rocks. They come green as a bank of emeralds, but with a fitful flying colour, as though conscious that in one moment more they would be dashed into spray and rise into air pale as driven snow. The vapour rises high into the air, and is gathered there, visible always as a permanent white cloud, over the cataract ; but the bulk of the spray which fills the lower hollow of that horseshoe is like a tumult of snow. To realise Niagara you must sit there till you see nothing else than that which you have come to see. You will hear nothing else, and think of nothing else. At length you will be one with the tumbling river before you. One of the great charms of Niagara consists in this—that over and above that one great object of wonder and beauty there is so much little loveliness ; loveliness especially of water, I mean. There are little rivulets running here and there over little falls, with pendent boughs above them, and stones shining under their shallow depths.

" Of all the sights in this earth of ours which tourists travel to see—at least, of all those I have seen—I am inclined to give the palm to Niagara. In the catalogue of such sights I intend to include all buildings, pictures, statues, and wonders of art made by men's hands, and also all beauties of Nature prepared by the Creator for the delight of His creatures. I know no other one thing so beautiful, so glorious, so powerful."

Edwin Arnold writes : " Close at hand on our left—not, indeed, farther removed than some six hundred or seven hundred yards—the smaller but very imposing American Fall speaks with the louder voice of the two, because its coiling spiral of twisted and furious flood crash in full impulse of descent upon the talus of massive boulders heaped up at its feet.

" The resounding impact of water on rock, the clouds of water-smoke which rise high

STIRLING FALLS, NEW ZEALAND

in air, while the river below is churned into a whirling cream of eddy and surge and back-water, unite in a composite effect at once magnificent and bewildering. But if you listen attentively you will always hear

the profound diapason of the great Fall—that surnamed the Horseshoe—rounding superbly amid the loudest clamour and tumult of its sister, a deeper and grander note; and whenever for a time the gaze rests with inexhaustible wonder upon that fierce and tumultuary American Fall, this mightier and still more marvellous Horseshoe steals it away with irresistible fascination. Its solemn voice—an octave lower than the excited, leaping, almost angry cry of fervid life from the lesser cataract—resounds through the golden summer air like the distant roar from the streets of fifty Londons all in full activity."

As we have already said, the Falls are gradually destroying the ledge over which they leap, and there can be no doubt that the seven-mile gorge, with its rapids and whirlpool, is a record of previous recession. Inch by inch, foot by foot, yard by yard, mile by mile, the industrious waters have undermined and eaten through a ledge of limestone that once extended as far as the end of the rapids; and still they are eating their way back. In the early decade of last century a great rock known as the Table Rock projected far out over the current below; but in 1850 the rock came down with a crash like thunder, and it was estimated that the dimensions of the falling rock were 200 feet long, 60 feet wide, and 100 feet deep. Not usually, however, by big mouthfuls like that does the Fall eat its way back; usually it is a matter of inches and feet. The average annual recession of the ledge of the Horseshoe Falls for the last sixty years or so has only been about five feet, and the average annual recession of the ledge of the American Fall has only been about eight inches. Still, year by year the Falls are retreating to the north, and in time the river will flow down a gradual gradient from Lake Erie to Lake Ontario.

KEPPLER CASCADE, YELLOWSTONE PARK

An endeavour has been made to calculate the age of Niagara by estimating the time it has taken to cut back from the end of the gorge to the present site of the Falls. From estimates of this sort, and other cognate considerations, the conclusion has been reached that the Niagara River must be about 32,000 years old. The data are, however, so uncertain that dogmatism is quite impossible, but probably Niagara is not less than 25,000 years old.

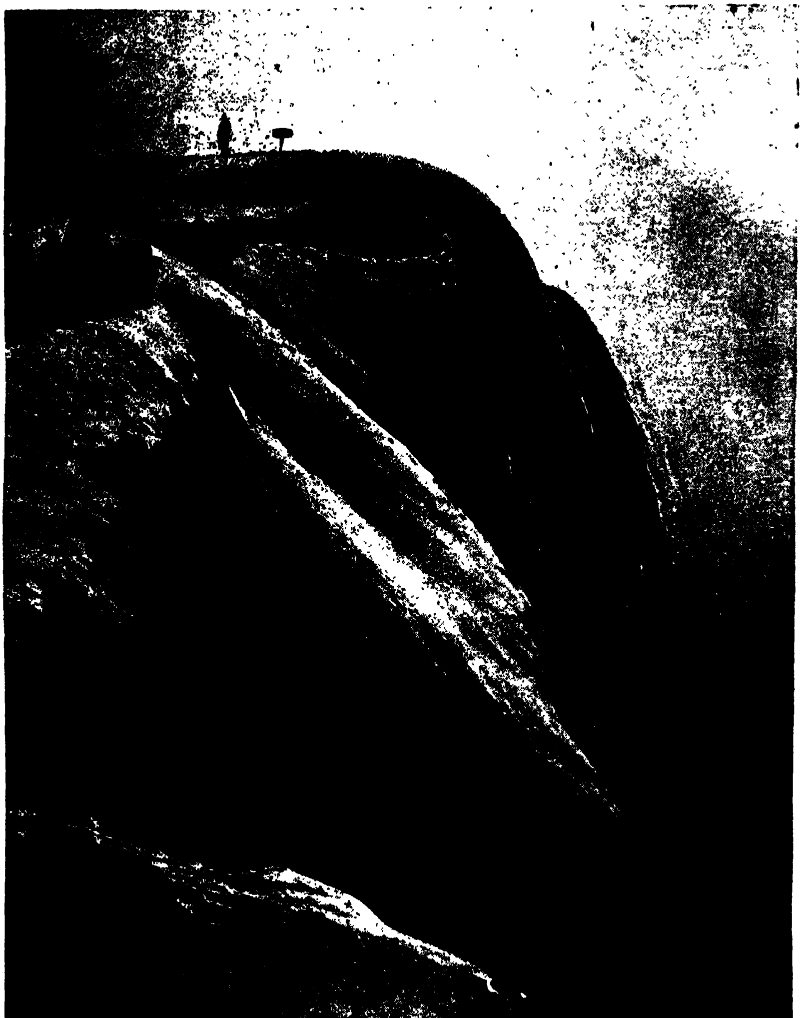
We have already mentioned the enormous power represented by the huge volume of falling water. The depth of the water as it passes over the crest of the Falls is not great, being less than 4 feet in places, and only 20 feet in the centre of the Horseshoe. The Niagara, which has carved this precipice out of the shale and sandstone, below its hard limestone escarpment, flows in a southward direction from Lake Erie to Lake Ontario, and is the sole outlet for the drainage not only of Lake Erie, but of Lake Superior, Lake Huron, Lake Michigan, and Lake Saint Clair. The amount of water behind it is therefore tremendous — ninety thousand square miles of reservoir area—and it may be doubted whether any other river in the world has such water reserves to draw upon it. Yet it is neither a long river nor a very exceptionally large river. Its total length from Lake Erie to Lake Superior is only thirty-three miles, its greatest breadth is only about three miles, and just above the Falls it measures less than a mile from bank to bank. Above the Fall there are

A CHARACTERISTIC WATERFALL, INLAND FROM BERGEN, IN THE VALDERS DISTRICT OF MID-NORWAY

THE VICTORIA FALLS, ON THE RIVER IGUAZU, ON THE ARGENTINE SIDE OF BRAZIL

THE FALLS OF THE RHINE AT SCHAFFHAUSEN, SWITZERLAND, AS SEEN FROM NEUHAUSEN

rapids with a fall of about 50 feet. The amount of scooping and excavation done by the Falls is by no means represented by their height, for the basin into which the waters plunge is fully as deep as the Falls are high, and extends for a mile and a half below the Falls. This great basin, like most pools below waterfalls, is filled with comparatively smooth water, so smooth that a little steamer, "The Maid of the Mist," is able to approach quite close to the cataract, and even rowing-boats are able to cross the basin. Below this great basin the river enters a gorge averaging only about a quarter of a mile in breadth and seven miles long. The sides of this gorge are steep, almost perpendicular, and from 200 to 500 feet high, and between its rocky walls the river rushes tumultuously along. Though the total fall in the gorge is only 100 feet, so great is the pressure behind the waters that they surge along at a rate of about thirty miles an hour, and present a spectacle of turbulent power equal to that of the Falls themselves. About half-way down the gorge the channel turns sharply to the left, and here the gyrating waters have worn a huge pot-hole known as the Whirlpool. In the Whirlpool there are vortices with tremendous powers of suction, so that even pine-trees are gulped down like straws. The depth of the Whirlpool is estimated as 400 feet. To many people the Whirlpool is the most fascinating feature of the Niagara Falls.



NIAGARA FALLS IN WINTER

Amazing and incredible as it may seem, a little vessel once passed safely down the gorge from the Falls, through the Whirlpool, to the open river beyond. In 1861 a little steamboat, called "The Maid of the Mist," undertook this terrible voyage to escape the sheriff. The steamboat was 72 feet long, 17 feet broad, and its engine was only of a hundred horse-power. This feat was, however, surpassed by Peter Nissen, who in 1900 actually went through the rapids as far as the Whirlpool in an open boat not inappropriately named "The Fool - Killer."

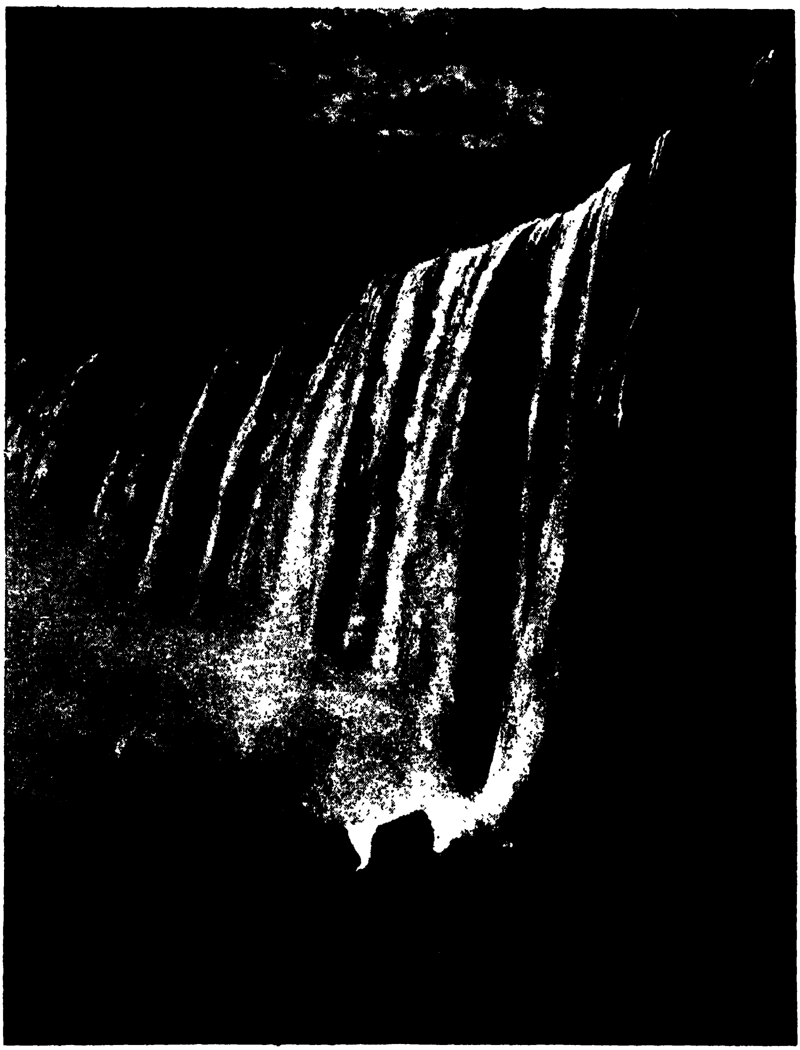
On July 2, 1883 Captain Webb, of Channel fame, attempted to swim the rapids, but disappeared in the boiling waters and was drowned. Undeterred by Captain Webb's fate, W. I. Kendall, a Boston policeman, attempted the same swim clad in a cork life-preserver, and succeeded in the attempt; while "Steve" Brodie, clad in an indiarubber suit, well padded and surrounded by thick steel bands

actually went over the Falls and escaped with his life. In 1886 an English cooper called Graham went through the rapids in a barrel, and numerous barrel-fiends soon repeated his performance; while in 1901 Mrs. Anna Edson Taylor safely passed over the Falls and was fished out of the pool.

Enormous though the volume of water in the Niagara River be, on one occasion in modern times it has run almost dry, so that one could walk dryshod from the American shore to Goat Island, and only a small streamlet flowed over the escarpment of the Horseshoe. The rapids were rapid no more, and the great Falls were reduced to a trickle. The giant who had chained the river was Frost. Broken ice on Lake Erie had been drifted by a gale towards the head of the river just where the river issued from the lake, and had quite cut off the exit of the water. For a whole day the River Niagara was thus deprived of its water supply; but towards night the barrier of ice melted away, and the river again flowed full to its banks.

The effect of frost on the Falls of Niagara is very remarkable. One would think that such torrents could not be chained, yet often the river below the Falls is frozen right across, and the blowing spray is piled up into miniature mountains 30 or 40 feet high, down which adventurous spirits make toboggan runs. In 1856 there was an ice-jam below the Falls, and the rapids below the Whirlpool were choked up with ice, which in some places was piled about 60 feet above the ordinary level of the current. Naturally, the ice in the neighbourhood of the Falls assumes beautiful and fantastic shapes. Stalactites and stalagmites adorn the rocks, and the trees and the bushes become converted into grotesque and wonderful statuesque apparitions. To many, Niagara in winter is more fascinating and marvellous than Niagara in summer.

Niagara may be the Queen of Waterfalls, but it has several rivals, both in beauty and in magnificence. Probably its most formidable rival is the Victoria Falls, on the Zambesi. Few things in the history of travel are more interesting than Livingstone's account of his first visit to these Falls. By the natives the great Falls were known as *Mosiotunya*, or *Smoke-sounds-there*, and a Makololo chief had asked Livingstone, "Have you smoke that sounds in your country?" Eager to see these wonderful smoking Falls, Livingstone sailed down the



NIAGARA FALLS IN SUMMER

Zambesi and in time came within sight of five columns of smoke-like vapour standing out white against the background of a wooded hill and ascending till they mingled with the clouds. The scene was extremely beautiful; the banks and islands were covered with luxuriant vegetation and blossom-spangled trees. He landed on an island in the middle of the river on the very edge of the Falls, yet he could not perceive where the river went. "It seemed to lose itself in the earth, disappearing into a transverse fissure only 80 feet wide. Creeping with awe to the extremity of the island, I peered down into a large rent which had been made from bank to bank of the broad Zambesi and saw that a stream of 1000 yards broad leaped down 100 feet and then became suddenly compressed into a space of 15 or 20 yards. The falls are simply caused by a crack made in the hard basaltic rock from the right to the left bank of the Zambesi and then prolonged from the left bank away through thirty or forty miles of hills . . . In looking down into the fissure on the right of the island nothing is visible but a dense white cloud which at the time we visited the spot had two bright rainbows on it. From this cloud a great jet of vapour exactly like steam mounted up to a height of 200 or 300 feet, and then condensing, changed its hue to that of a dark smoke, and came back in a constant shower, which soon wetted us to the skin."

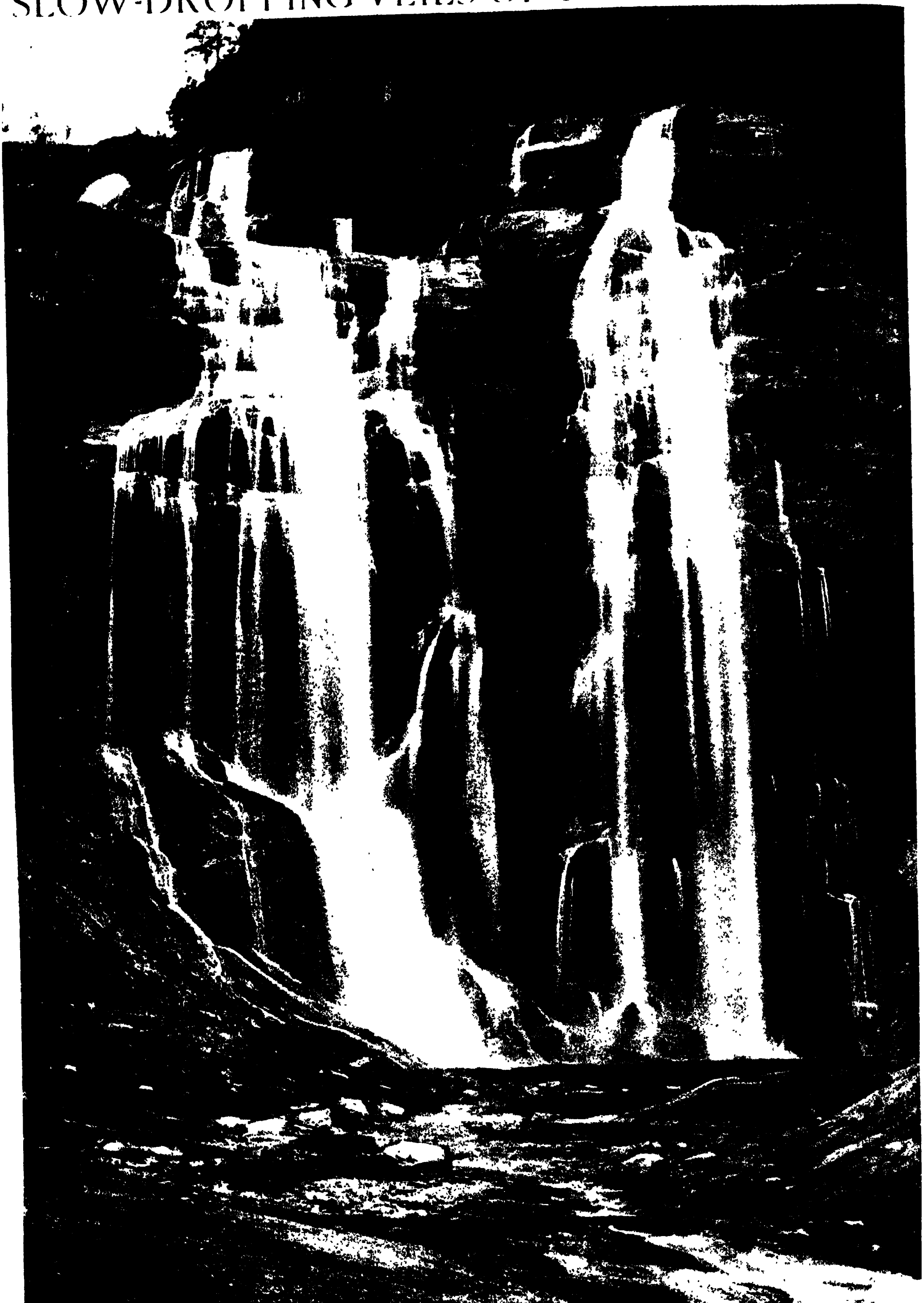
NEVADA FALLS, IN THE YOSEMITE VALLEY

STAUBBACH FALLS, SWITZERLAND

The rainbows in the spray are a special feature of the Victoria Falls, so much so that the Falls were formerly known to the natives as Seongo or Chongwe, the place of the rainbows. Out of the great cauldron of foaming waters the mist arises like smoke 1000 feet or more into the air, and ever in the mist shine double and treble rainbows. The mist, sometimes grey, sometimes ruddy, sometimes orange, sometimes sulphur-coloured, the rainbows gleaming in it, the foliage gleaming through it, the foaming waters down in the abyss, make a colour-scheme of incomparable beauty.

Since the time of Livingstone, the Falls have been carefully measured and mapped. Between the right bank and the island of Boaruka is a fall of water 36 yards wide, known as the Devil's Cataract. Beyond the island of Boaruka is a fall 900 yards wide, divided in two by a projecting rock. Then comes Livingstone Island, and between Livingstone Island and the eastern bank is the Eastern Cataract, 600 yards wide. The height of the Falls varies at points from 256 to 343 feet in depth. The width of the great chasm is from 80 to 100 feet at each end, and 240 feet in the centre. The gorge into which the foaming waters rush is only about 100 feet in width at its entrance, and zigzags along for about forty miles. The Falls are accordingly wider and higher than the Niagara Falls, and the gorge is longer. Livingstone conjectured that both the great chasm and the zigzag cañon were made by a rending of the earth, but geological

"SLOW-DROPPING VEILS OF THINNEST LAWN"



THE DAINTILY GRACEFUL SKJERVEFOS, IN NORWAY, BETWEEN EIDE AND VOSSEVANGEN

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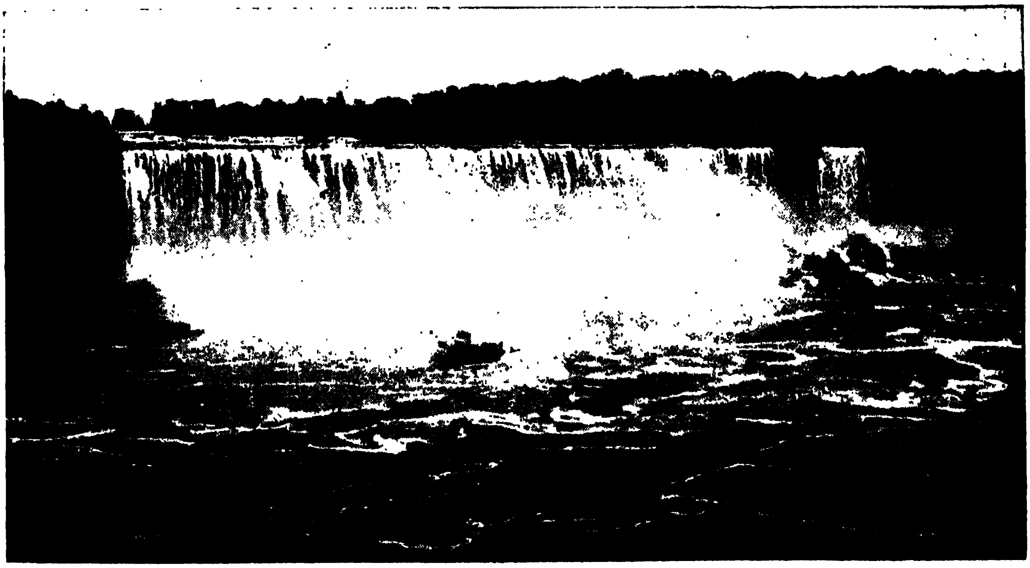
authorities are of the opinion that the cañon has been carved out by the river eroding its way along joints and lines of weakness in the basalt, and must have required some hundreds of thousands of years for its making. As a source of power the Victoria Falls surpass Niagara, and schemes have been proposed to harness them to the mining mills in Johannesburg, hundreds of miles away, but so far the Falls have es caped such servitude.

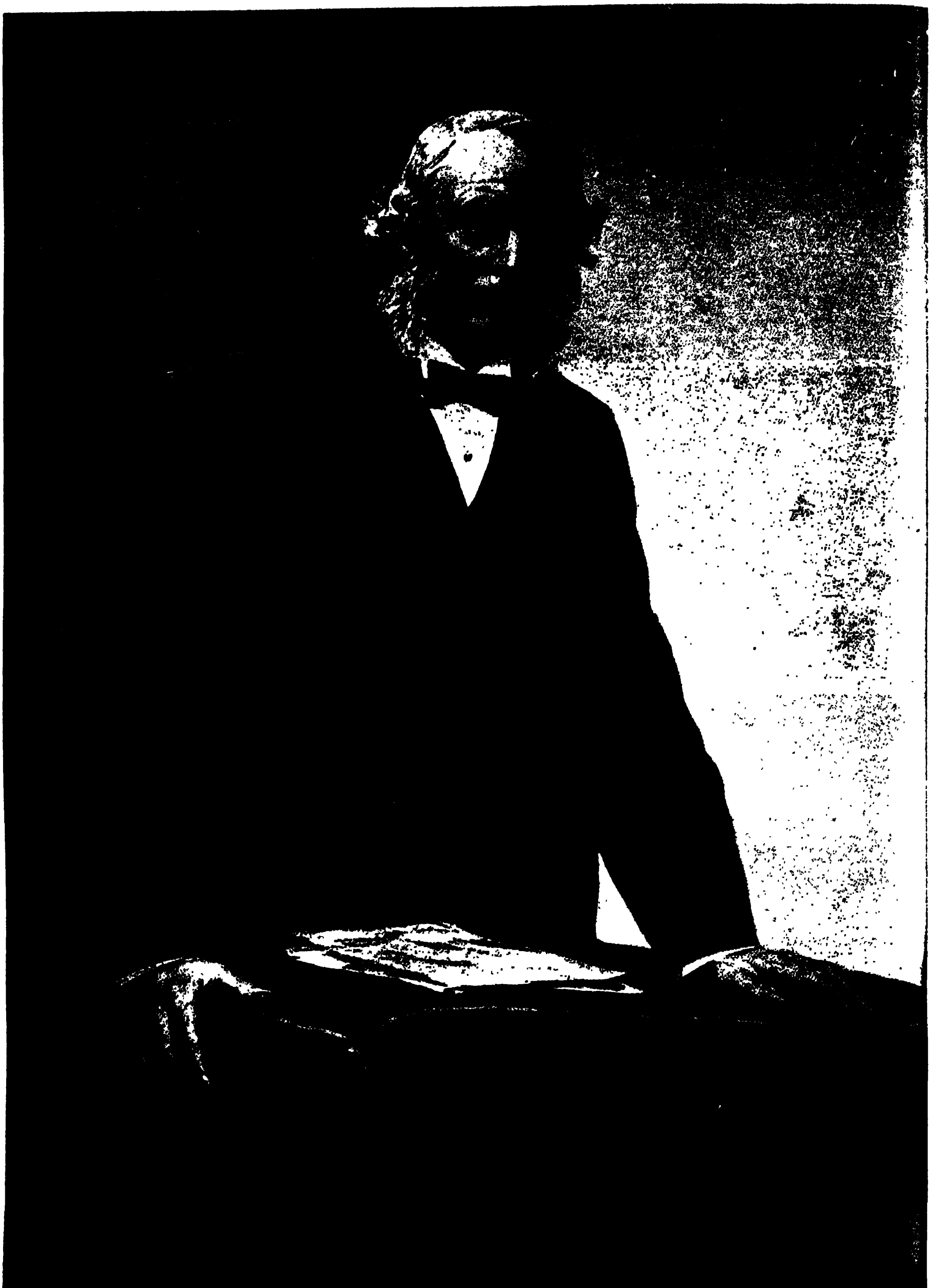
The third great falls of the world are the Falls of Kaieteur, on the Potaro River, in British Guiana. They were discovered by Mr. C. B. Brown, only forty years ago. Mr. Brown, in a communication to the Royal Geographical Society, described the Falls: "Kaieteur Fall is produced by the Potaro River flowing over a sandstone and conglomerate tableland into a deep valley below, with a total fall of 822 feet. For the first 741 feet the water falls as a perpendicular column into a basin below, from which it continues its downward course over a sloping cataract in front, 81 feet in height, and through the interstices of great blocks of rock to the river-bed below."

A year or two later Colonel Webber visited it, was greatly impressed by its beauty and grandeur, and considered it far finer than Niagara. "On seeing the Kaieteur," he writes, "in its full glory, lit up by a brilliant sun whose rays, piercing the mist rising from the bottom more than 700 feet far down, produced a rainbow, every hue of which was reflected in the torrent, my first impression, and I believe exclamation, was, 'This is far grander than Niagara.' . . . What the Kaieteur loses from a comparison with Niagara in width and in magnitude of the descending flood it gains in height, while the surrounding scenery is far lovelier." The peculiar clear brown colour of the water, due to tannin in solution, gives the falling water characteristically beautiful tints of varying brown and orange. Altogether the Kaieteur Fall is certainly one of the great falls of the world; and since waterfalls mean power as well as beauty, it is gratifying to think that the Niagara, Victoria, and the Kaieteur Falls belong to Anglo-Saxon nations.

The Victoria Falls are about twice as high as the Niagara Falls, and the Kaieteur Falls are more than twice as high as the Victoria Falls, but there are many falls higher still than the Kaieteur Falls. The Bridal Veil Fall, in the Yosemite Valley, has a vertical descent of 1000 feet; the Yosemite Fall leaps 1500 feet; while the Keelfos Fall, in Norway, which is the highest perpendicular fall in the world, has a sheer descent of 2000 feet. Neither height nor volume, however, is the deciding factor in the impressiveness of a waterfall: height often takes away from the full effect of the fall. Thus, the Yosemite Fall, which is about 40 feet wide, looks like a mere thread to the observer in the valley. Many think that the Nevada Falls, in the Yosemite Valley, are really the finest in the world. These falls are very great in volume, and leap 640 feet.



THE "MAID OF THE MIST" STEAMING BELOW THE AMERICAN FALLS, NIAGARA



LORD LISTER, THE FOUNDER OF ANTISEPTIC SURGERY, LECTURING BEFORE THE ROYAL SOCIETY

LISTER & MODERN SURGERY

The Wonderful Cures Made Possible by Listerism with Little Pain or Danger

LESSONS OF LIFE OF THE JAPANESE WAR

In the last chapter we saw that, during the first half of the nineteenth century, man had largely achieved the conquest of pain. Thereafter the surgeon was not so pressed for time, and could be more secure; operations formerly impossible could be attempted; patients formerly too fearful could submit to the knife. But if we attempt to estimate the value of anæsthesia in terms of human life as against that of other species, we find it disappointing. The surgeon's patients still died in large numbers; surgery was still a desperate remedy for desperate diseases. The poor fellow who was carried into hospital from the railway line with a crushed leg could have it removed painlessly, and then, a little later, have a second amputation performed higher up, also painlessly, but too often he would die. Something was at work for which anæsthesia was irrelevant. It made operations vastly more possible, and we could say that an operation had been "successfully performed," but the results were still deplorable. One in three was the death-rate after major operations.

In the 'fifties and 'sixties these matters came to be considered by a young surgeon with a brain as well as hands, named Joseph Lister. The surgeon's enemy was *inflammation*. Instead of healing "by first intention," as a tiny cut upon the finger will usually do, wounds became inflamed; and somehow this inflammation affected the whole vigour of the patient, so that often he died. The classical symptoms of inflammation are ***rubor*, *calor*, *tumor***, and ***dolor***—redness, heat, swelling, and pain. Lister devoted himself to the study of these symptoms. No one knew their cause, but they suggested a kind of chemical process in the inflamed tissues—as if a sort of slow combustion were going on. Now, combustion is fed by the oxygen of the air. Hence a reasonable suggestion was to try to keep the air away from wounds, in order that they might not become inflamed. Many devices were employed to this end—uselessly. The air had just the same relation to surgical inflammation as the "malaria" of the night and the swamps has to infection by the malarial mosquito. Then there came the great demonstrations of Pasteur. Let no mistake be made here, while we honour the great Englishman of whom it has been said that he saves more lives in every year than Napoleon took in all his wars. The discoverer was Louis Pasteur, the chemist, and, to boot, the greatest physician, the greatest surgeon, the greatest midwife of all time. The rare merit of Lister was that he had the brains and the courage to become the foremost of Pasteur's pupils.

Pasteur found that microbes could cause processes of fermentation, including the production of heat and of swelling, in various fluids and mixtures. If, then, exclusion of the air was unavailing to prevent surgical inflammation, with its similar features, perhaps exclusion of microbes, or the killing of them, might have the desired effect. So Lister argued. Pasteur himself argued in the same way, and used to "sterilise," as we now say, his needles and instruments by means of a flame, for his experiments upon animals, just as the surgeon does today when operating on men or animals. But Pasteur did not practise human surgery, and had his own work to do. Lister decided that he must obtain some compound which would arrest *sepsis*, or putrefaction, as it occurs in inflamed tissues; and when he sought chemical help for the purpose he was offered, at the very first, by Mr. Calvert, whose name is still familiar, the compound called carbolic acid, not yet surpassed for most purposes. As this substance opposed sepsis, Lister

called it an antiseptic, and his use of it, for surgical purposes, *antiseptic surgery*.

At this time Lister held a Chair of surgery in Glasgow, and there his first experiments were made. The obvious opportunity for them was in such cases of compound fracture as we have already quoted for purposes of illustration. They commonly involved sepsis. The mark of a compound fracture is that the injury involves a channel from the surface of the broken skin right down to the broken bone. Thus the inflammatory, and soon septic, process appeared in the bone itself, and rapidly spread upwards. Often the surgeon, after repeated amputation, failed to arrest it. Perhaps carbolic acid would help him. While performing his amputation (but nowadays he often does better than amputate at all), let him freely use carbolic acid; let the stump of the sawn surface of the bone be so treated also; and if microbes are really the cause of sepsis, and the carbolic acid kills them, the septic process should cease. And so it happened. Lister's earliest series of results were the best that had ever been obtained in human history.

The Story of Lister's Experimental Advance Towards Antiseptic Surgery

He was appointed Professor of Clinical Surgery in Edinburgh, and there he worked out in detail the principles of antiseptic surgery, greatly aided by his right-hand man, Professor John Chiene. Lister was very thorough in his methods. Little was then known about the behaviour and *habitat* of the microbes of inflammation and putrefaction. They were supposed to be omnipresent, which they are not, although it is a very good rule to assume that they are. Lister told his pupils to act as if every surface of every object, without exception, were covered with "wet green paint." Nothing was to be touched, for infection was possibly anywhere. It was supposed to be in the air, which was figured as full of floating microbes of putrefaction. Lister therefore invented a carbolic acid spray, which injected a fine shower of the antiseptic fluid into the air above the patient and all over everything concerned.

Soon the spray was abandoned, and the results were just as good, or better. Lister meant to make no mistake about his antiseptic measures, but soon he found that not only the spray, but also the great strength of his solutions, was superfluous. Weaker solutions possessed the same almost magic power, and the results became better still. The *Times* made the happy observation that Mr. Lister's arguments became stronger as his solutions grew weaker. The reason is simple enough. Carbolic acid is a poison to every form of life, a "protoplasmic poison." It not only kills microbes, but also devitalises the cells of the tissues which the microbes are attacking. Further, it is to some extent and in certain conditions absorbed into the patient's blood, and there acts as a poison. Fatal cases of carbolic acid poisoning have thus been recorded in the past. Hence weaker solutions, provided that they were strong enough, provided stronger arguments, because they produced better results.

The Controversy on Cleanliness Between Lister and Lawson Tait

Lister had some important critics, notably the famous Birmingham surgeon Mr. Lawson Tait. This remarkable man obtained very good results, in many serious cases of certain kinds, without the use of antiseptics, but with the use of abundant washing and what may be called domestic cleanliness. These were cases where no microbes were present in the first place—cases of what surgeons call "unbroken skin"—and Tait's results, which could never have been obtained in, say, dirty compound fractures, were very significant indeed. He and his followers denounced the microbe theory altogether; and the opponents of vivisection—without which Pasteur could not have made his discoveries—supported Tait against Lister.

The real meaning of the facts was not long in doubt, as Lister proved. Where no septic microbes are, and where none are introduced, no antiseptics are necessary, for there is nothing to kill, no work for them to do; and as they tend to weaken the powers of the patient's tissues, they are better absent altogether.

The Transference of Antiseptic Treatment from the Patient to the Surgeon

Hence, Lister developed an antiseptic surgery, for cases of "unbroken skin," to which he gave the name of "aseptic surgery"—that is, surgery without sepsis altogether. The case is surgically clean, or aseptic, at starting, as when the surgeon breaks rickety bones in order to set them straight, and so cure a bad case of knock-knees. To treat the broken bones with carbolic acid in such a case would simply be to injure them and retard the new union of the bones, provided that the surgeon has never introduced any microbes where none were when he began. He therefore performs an aseptic operation, the point of which is

that, while antiseptics are freely employed for his own fingers, for his instruments, for the clothes he wears, and while the skin of the patient is treated with them for many hours before the operation, so as to sterilise it, at the operation itself the antiseptic is washed away, the surgeon's fingers and instruments are all rinsed in boiled water after the use of antiseptics upon them, and thus no particle of any antiseptic comes in contact with the tissues of the patient. In consequence, they heal more rapidly, and neatly, and painlessly, and perfectly than under any other conditions.

The Opposition to Listerian Methods from Anti-Vivisectionists

No distinction in principle exists between the two methods, and only this one small, but useful, distinction in detail. Lord Lister has, however, been repeatedly attacked, in the interests of anti-vivisectionists, as having, in fact, abandoned as useless the theories which were based by him on Pasteur's experiments, and as having covered up his abandonment of those theories, and his discovery of their falsity, by inventing an "aseptic" system, which is merely the old practice of cleanliness under a new name. This allegation against Lord Lister is simply untrue, and without even a vestige of warrant or excuse. The facts, as they may be verified in any hospital in the world, on any day, and at almost any hour, are as we have stated them. Besides being the greatest surgeon that ever lived, Lord Lister was a man of the most stainless honour; and if his theories had been found false—as, fortunately for mankind, they were not—he would have surely acknowledged his error. On the contrary, every month of every year, from 1868, which marks the introduction of carbolic acid into surgery, up to the present day, has witnessed increasing justification for a method which has, during the same period, steadily advanced in perfection of detail, but in nothing else.

The Abolition of Inflammation as an After-Effect of Surgery

Lister's establishment of the antiseptic principle, during his magnificent years in Edinburgh, at once transformed the nature of surgery. He introduced the catgut ligature, in place of silk ligatures, and could completely close his wounds at the end of an operation, in many cases; for after a little while, when the vessels tied with catgut had closed by natural processes, the catgut itself, being an animal tissue, was absorbed by the animal body in which it found iteslf, and so there was nothing left to come away after the operation was performed. In Denmark and in France Listerian methods were quickly adopted with success; and at last, when Listerian surgery was succeeding in the north, the east, and the south, the surgeons of London began to accept it. The essence of it was that inflammation practically vanished from surgical practice.

The four classical symptoms of inflammation were all due to a struggle for existence, waged in the patient's tissues, between them and microbes. That is the meaning of inflammation, in biological language. The particular kinds of microbes involved belong to the round type, called cocci, and the most important are a coccus which grows in chains, a kind of *streptococcus*, and one which grows in clusters like grapes, a kind of *staphylococcus*. Only too frequently, when these creatures have established themselves locally, they spread throughout the body, and hence we have the various forms of so-called "blood-poisoning," named pyæmia, sapræmia, and septicæmia—diseases where, as the names suggest, the very blood seems to suppurate and putrefy.

What Happens in the Case of Injury from a Rusty Nail

When we hear that a man scratched himself with a rusty nail, and contracted blood-poisoning, we should know that rust is itself an excellent blood-tonic, which could do nothing but good; in fact, people with plenty of "rust" in the blood are those who are least easily poisoned, by "rusty nails" or otherwise. But some of the cocci we have named have invaded the wound, have there multiplied, and blood-poisoning, by them and their products, and not by the incidental rust, is the result.

Blood-poisoning, the sequel to local inflammation, was the bane of surgery. But Lister stopped all that. His personality and his practical success were as nearly magical or superhuman as anything in the history of man. Among his patients, in the "Old" Royal Infirmary of Edinburgh, was the famous poet and author W. E. Henley, who wrote a series of poems called "In Hospital." One of these, a sonnet entitled "The Chief," gives a picture of Joseph Lister which should be remembered when men propose to put up monuments of brass and marble to the great surgeon.

The battlefield and the military hospital are perhaps the first places where Listerian surgery, antiseptic rather than aseptic, may

be expected to benefit mankind. Lister introduced carbolic acid in 1868, just in time for the Franco-Prussian campaign of 1870-71. But military authorities move slowly; and though Pasteur was a Frenchman, and antiseptic surgery is simply the application of Pasteur's essential discovery that microbes cause disease, neither the French nor the scientific Germans used carbolic acid in that war. Chloroform, mercifully, was there, but it had had nearly a quarter of a century in which to make its name heard in War Offices. Some thirty years after the introduction of carbolic acid, the Boer War began, and in that unhappy and tragic business carbolic acid played a part. Professor Chiene, Lister's "right-hand man" in the pioneer years in Edinburgh, went to South Africa, and did his best, like Sir Frederick Treves and many other Listerians. But the conditions were impossibly bad. None of those in authority, whether at home or in South Africa, had any real belief in science. The most elementary ideas, long established by Pasteur and Lister, were ignored. Camps were pitched on typhoidal drainage, the men drank indescribable water, the supply of surgical necessaries was tragically inadequate; and the great principle against which the representatives of science and the champions of life had to contend in that deadly campaign was the dictum of an illustrious soldier (not himself engaged in South Africa) that "Medical advice is a very good thing—when it is asked for."

The Failure of England and Success of Japan in Adapting Surgery to Warfare

The truth, however, is that medical advice is never such a good and necessary thing as for those who are too ignorant even to ask for it. How different the history of that campaign would have been, with the principles of Pasteur and Lister enforced, we can scarcely begin to imagine. But, of course, more deaths and invalidism were due to neglect of those principles that to the Boer bullets. Though Lister was an Englishman, we did not do so very much better than the countrymen of Pasteur thirty years before.

Then came the Russo-Japanese War, and a very different story. So far as the Europeans were concerned, the science of Europe might not have existed. There were plenty of *ikons* for the sick, but none of that more profound religious worship which we see in the practice of science for their healing. The "yellow monkeys," as Pasteur's fellow-countrymen called them, had the monopoly of Pasteur's principles, and they bettered all their instruction. The war resolved itself into a question of man-power; and it came to an end when Japan's resources of men were all but depleted. But those resources had been maintained by unprecedented means, and with unprecedented success. Never in the records of war was there so little typhoid, so little dysentery, such a small proportion of deaths from wounds, as on the Japanese side. The sheerly surgical—*i.e.*, cheirurgical—"hand-workical"—qualities of the Japanese may be guessed from their skill in artistic technique. But this was not the key to the Japanese records. They succeeded because they *really believed* in what they had learnt from Western science.

The Japanese Use of Sterilised Underclothing in Battle

Now here, as elsewhere in scientific practice, it is the details that make the difference. A surgeon's Listerian theory may be sound, but if he wears a beard, or touches his cheek with his finger while operating, his practice may be a disastrous failure. Where we are dealing with microscopic, almost ubiquitous enemies, a slap-dash antisepsis is not good enough. The Japanese were thorough, as a single illustration will show. A few years earlier, their soldiers and sailors had fought in the quaintest mediæval or barbaric armour possible; it was exhibited in London at the recent Anglo-Japanese Exhibition. But now, before a naval engagement, the sailors were compelled to take carbolic baths and to don sterilised underclothing; so that they stood up to the Russian guns in the full modern panoply of a boiled vest and a carbolised skin.

Why More Wounded Recover in War than Ever Before

Modern projectiles, be it observed, are sterile. The temperature at which they are propelled, their rapid flight, and the atmospheric friction guarantee that. If they do not touch a vital spot—and only a small part of the body is vital in that sense—they can only kill by inducing inflammation; and the only source of such inflammation must be microbes in the skin or clothing of the patient, part of which is often carried into the wound. But the Japanese who prepared themselves on Listerian lines were protected; the operations performed on them by the Russian projectiles were modern aseptic operations, of the very newest kind, and

the rates of death and injury corresponded. Never before in the history of war did such a large proportion of the wounded return to the fighting ranks.

We begin to see the meaning of the verdict of Sir Frederick Treves, who had opportunities for judging, that *Lord Lister won that war.* This singular achievement for an English Quaker should, no doubt, be more properly put down to the supreme genius of his French master, but a great surgeon may be excused for remembering his own master's name first. The real makers of human history now begin to appear. We have already seen that, though Lesseps failed, it was a Frenchman, after all, who made the Panama Canal, and that same Frenchman preserved the autonomy of Japan. True, indeed, is it, though in a new sense, that "the dead rule us from their urns."

SURGEONS IN TOKIO OPERATING ON A SOLDIER WOUNDED IN THE RUSSO-JAPANESE WAR

The achievements of Listerism under the more favourable conditions of civil life must briefly be indicated. They depend primarily upon the provision of suitable places, such as no private house is equipped with. Not many years ago, surgical theatres were built to accommodate many spectators, to be counted in hundreds. One such, in Edinburgh, wherein many of the earliest abdominal operations were performed, should be seen to be contrasted with the theatres built nowadays. It has not been used for surgical operations for many years. Excellent examples of the modern theatre are furnished in St. Thomas's Hospital, in London, where a pair of twin theatres were opened by Lord Lister himself some years ago. These are relatively small, with polished tiles, equipped with every necessary, including such *minutiæ* as pedals to turn the water-taps, so that the surgeons do not need to contaminate their fingers; but the regulations are as important as the fittings. The visitor must don Wellington boots, provided for the purpose, before he touches the floor, for this, like a Mohammedan mosque, is holy ground, sacred to the service of Life, and there must enter nothing that "defileth."

That, however, is only when the theatres are not being used. During operations the half-dozen or so spectators, for whom alone accommodation is provided, must enter by a special door, rather like visitors to the House of Commons; nor are they allowed on the "floor of the House." You may go to the House of Commons from anywhere, however—why not, indeed?—but no one may come to these theatres from the dissecting-room, the post-mortem room, or infectious wards, as prominent notices on the doors declare. The patient and those who are to serve him enter by another door, at the other side of the theatres. There is an ante-room where the anæsthetic can be given—a humane arrangement, which averts much nervousness in many cases. The air which enters the theatres is driven in by the *plenum* system, having first been filtered by passage through a curtain of cocoa-nut fibre, down which water streams, and its temperature is regulated and kept constant. Patients under an anæsthetic, like persons under alcohol, are liable to catch cold. Finally, we may observe that the current of air is so directed that it reaches the patient first, and then passes from him past the spectators and away. They therefore may possibly receive anything he has to offer them, but nothing they bring in with them can very well reach him.

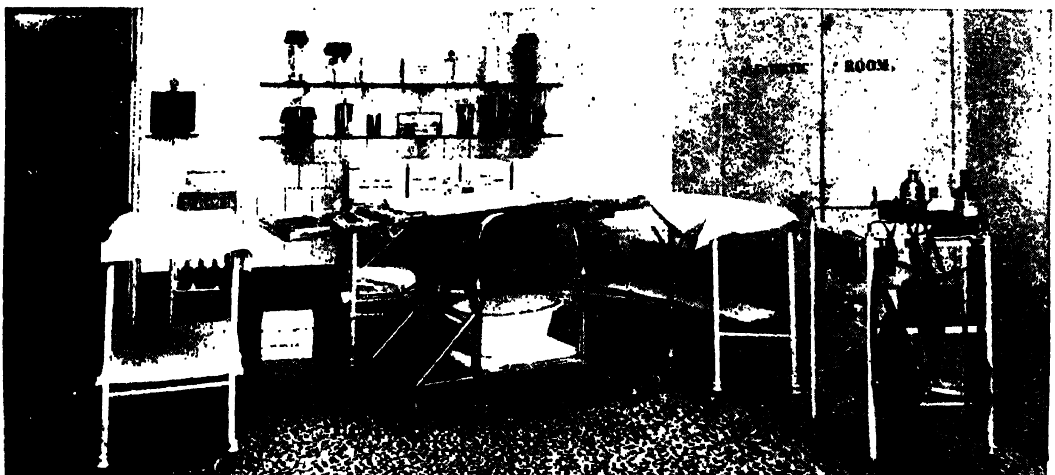
Note, further, that there is a bacteriological laboratory in the hospital, associated with these theatres. The surgeons and their patients are largely at the mercy of the official whose business it is to sterilise everything concerned with the operation —the instruments, the lotions, the water, the swabs, the aprons, blouses, and caps

used by the surgeons and their assistants. Where asepsis is aimed at, technique must be perfect, for there is not a free flow of carbolic or mercurial lotion to destroy any microbes which might perchance have reached the patient's wound. Therefore, whenever he will, the surgeon will send an instrument, a swab, a little lotion, down to the laboratory to see whether it is really sterile, as it should be, or whether living microbes can be cultivated from it. Not only so, but he must check the elaborate methods which he employs for sterilising the skin of the patient, and his own fingers. How good the modern methods are, with their sequence of nailbrush, and turpentine soap, and ether to melt away the fat, and carbolic lotions, etc., we can guess when we look at the records, and find that, say, for a year at a time, not once have any living microbes been obtainable from the skin of either patients or surgeons after their employment.

Under such conditions it becomes possible for the surgeon to go where he pleases. Listerism soon advanced beyond lowering the death-rate after amputation for compound fracture. Nowadays, the fracture may, indeed, be so well cleansed with antiseptics, the patient being anæsthetised while the task is thoroughly done, that the limb is saved as well as the life. Abdominal operations were soon attempted with success. Not far short of a hundred thousand operations are said to be performed for appendicitis in this country alone every year. Formerly, the inflammation continued to spread, and the patient died of what was called, and was, peritonitis, but its origin was in the appendix, which the surgeon can now reach and deal with. As for compound fractures, the writer has often seen four *made* by the surgeon at one operation, one above and one below each knee; and when the bones had healed in the new position which the surgeon imposed upon them, the patient's knock-knees had vanished, and he was some inches taller. For those who know what a compound fracture used to mean before Lister put carbolic acid on them, this particular operation is as eloquent as any in teaching what Listerism means.

The surgery of the heart is one of the triumphant advances of recent years. A case was recorded in Berlin, not long ago, when an accident caused a *perforating* wound through the wall of the heart, but the surgeons were able to sew it up in time, and the patient recovered—the first man that ever lived to tell such a tale. Sir Lauder Brunton, the distinguished physician, has lately speculated as to the possibility of getting the surgeon to insert a fine knife into the heart and slit open the contracted valve which is responsible for certain forms of heart disease. This has not been, and perhaps never will be, attempted. We shall sooner have antitoxins for the rheumatic and other microbes which set up the inflammatory process that contracts the valves; but the fact that it has been suggested by a world-famous student of the heart is another measure of the possibilities of modern Listerism.

More remarkable, and of a vastly greater

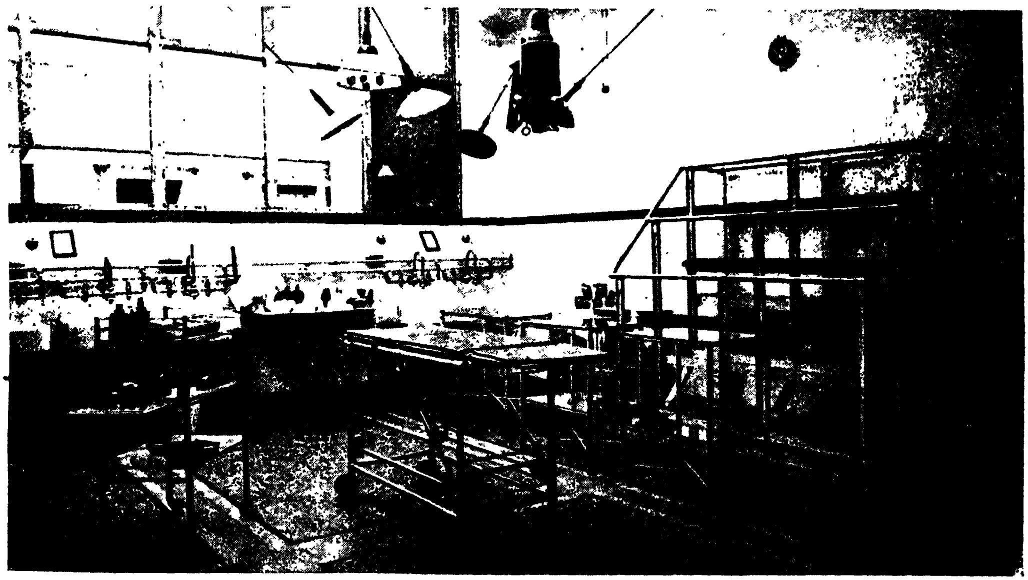


WHERE CLEANLINESS IS LIFE—AN OPERATING THEATRE IN ST. BARTHOLOMEW'S HOSPITAL, SHOWING THE OPERATING TABLE AND THE DOOR OF THE ROOM FOR ADMINISTERING ANÆSTHETICS

daily value, is the modern surgery of the brain. This, of course, involves making a compound fracture of the skull, but that is no matter nowadays, when the surgeon is sure of his aseptic technique. Thereafter the surgeon may deal with tumours, tuberculous abscesses, bullets, portions of bone carried into the brain from a previous compound fracture, and many other conditions. Attempts have even been made to "minister to a mind diseased," as, for instance, in cases of microcephalous, or small-headed, idiocy, where it was thought that the small development of the brain depended upon the premature arrest of the growth of the skull, and where, on that view, attempts have been made to deal with the skull, so that the brain might have room to grow. We are now assured, however, that the brain condition comes first in these cases; its failure to grow further leads the skull to close, for there is no reason why it should longer remain open, and thus operations on the skull in such cases are of no use. Other cases are recorded where surgical operations have relieved certain forms of insanity, but these are exceptional and dubious.

The pioneer and acknowledged master of brain surgery is Sir Victor Horsley, whose initial researches upon the functions of various parts of the brain in the lower animals led the way to his work upon the human brain in states of disease. It is particularly to be noted that Listerism has made surgery, humanly speaking, safe. Further, by preventing inflammation, it has averted the pain which used to follow operations, and for which the beneficent discovery of surgical anæsthesia was of no avail. It follows that operations, even upon the brain, need by no means be confined to cases where life is in danger.

Perhaps the most remarkable and celebrated achievement of Sir Victor Horsley has been the surgical relief of cases of extreme facial neuralgia. In elderly people especially, neuralgia, having its seat in the fifth cranial nerve of one side or other, may become so intolerable that life becomes worthless, and the patient's plight is too miserable for description. In these cases all medical and medicinal measures are often unavailing. Portions of the affected nerve may be reached by surgical procedure, and divided, sometimes to the partial relief of the patient. But it appears that in such cases the seat of the mischief is higher up, in a ganglion, or collection of nerve-cells, which is practically part of the brain, and lies under cover of a lobe of the brain within the skull. The operation has therefore been successfully devised of opening the skull, turning aside the intervening portion of brain, and excising this "Gasserian ganglion," as it is called, altogether. The difficulties of this proceeding cannot be demonstrated except by witnessing



AN OPERATING THEATRE AT THE LONDON HOSPITAL, SHOWING THE STUDENTS' GALLERY, AND THE ELABORATE ARRANGEMENTS FOR SECURING PERFECT ASEPTIC CONDITIONS

the operation, but its success is patent. The first case the present writer saw was in an octogenarian man, who, notwithstanding his age, bore the operation splendidly, without any evidence of shock, and whose age showed that Listerian surgery, especially where the aseptic technique is applicable, involves extraordinarily little strain upon the vital resources of the patient. *No poisoning is involved*, and there lies the whole secret of its success.

The principles which apply to the largest proceedings apply to the smallest. The causes which lead to the extraction of teeth, for instance, are essentially microbic. There may be an infection of the pulp of the tooth, a "pulpitis," as dentists call it. For this the old remedy was extraction alone. But the modern dentist can attack this problem, just as the modern surgeon would attack a similar inflammation in the marrow of a bone. The pulp can be reached and cleaned out, an antiseptic dressing may be applied, and then the whole cavity may be plugged, and the tooth saved for many years to come.

The Variety of Operations for which Listerian Methods are Suitable

Listerian dentistry, like Listerian surgery in general, is thus, like all other valuable things and people, at once conservative and radical. If it is valuable to the dentist, it is more so to the oculist. Inflammation is a desperately serious matter in the eye, and may utterly ruin the sight for ever in a few hours, to say nothing of the extreme liability of the other eye to go the way of the first. But now the ophthalmic surgeon can perform the most delicate operations without fear, provided that his patient will take reasonable precautions to prevent infection afterwards.

The surgery of the nose and throat has benefited in just the same way. A certain percentage of people, for instance, have what is called a deflected nasal septum; the bony and cartilaginous partition or septum between the two sides of the nose is deflected, so that microbes are apt to lodge in the nose; there is great liability to colds, and in time the voice and bronchial tubes are secondarily affected. No satisfactory treatment for this condition existed until a few years ago, when a Viennese surgeon invented a bold but effective operation. The nose is painted with cocaine and adrenalin, the surgeon makes a flap of the mucous lining of the nose, and removes the entire septum bodily, or rather in pieces of cartilage and bone, with the aid of knife and chisel and hammer. The flap of mucous membrane is then laid down and held with a single stitch, and the patient has a merely membranous partition to the nose for the rest of his days. The benefits of this operation have to be experienced to be realised, as the present writer knows on his own account. Of course, such an operation, with its chiselling of bony structures right up to the base of the brain, would be unthinkable without the protection afforded by Listerism.

The Use of Listerian Precautions in Removing Superficial Blemishes

All sorts of minor possibilities need barely be menitoned. Skin-grafting becomes possible, and is, indeed, not a minor possibility in cases of extensive burning. The whole of the skin of the back has thus been replaced, after a long time and much trouble, in a case where a burn had destroyed it. Hence we may pass to merely "cosmetic surgery," the grafting of ears and noses, and so forth. Much may nowadays be done, under Listerian precautions, for the removal of facial and other blemishes, nor need the surgeon regard such procedures as beneath his dignity. They may make all the difference to a life's happiness; and if they are left to those who have no knowledge of Listerism, inflammation and worse disaster is apt to follow attempts to remove or cauterise moles and warts, and port-wine stains and so forth. A curious and interesting illustration of what the body will tolerate, so long as the procedure is Listerian and microbes are not involved, is furnished by the measures successfully taken for the introduction of paraffin under the skin of the nose in order to restore it to a seemly shape in certain cases. The body is not resentful of foreign substances, and no inflammation is aroused so long as the struggle for existence between one living species and another—the body and microbes—is not involved.

The Natural Antiseptic Agents in the Body Revealed by Metchnikoff

The great work done at the Pasteur Institute by Metchnikoff and others has shown, since the introduction of antiseptics, that the body contains its own natural antiseptic agents; above all, the white blood-cells, or "phagocytes," as Metchnikoff calls them, and the ferments which these "eating cells" contain. The study of the blood thus becomes a matter of the first importance for the surgeon. For instance, in appendicitis, the surgeon may hope that no suppuration will occur, and that he will not need to interfere until the attack has

subsided, and the appendix may be removed conveniently and safely, with the patient in good condition and well prepared. But he must make periodic and perhaps four-hourly counts of the cell-content of the blood, for he knows that, if the number of phagocytes rises markedly, this is the body's response to commencing suppuration, and he must interfere at once, lest the pus infects the peritoneum and kills the patient.

The Certainty of Scientific Inference from the State of the Blood

Similarly, the writer has seen a surgeon explore a small boy's thigh, where pain was complained of, on the ground that the number of phagocytes in the child's blood was excessive, and therefore suppuration was commencing somewhere. When the thigh-bone was reached, nothing was to be found, but the surgeon had faith in the blood-count, and, penetrating to the interior of the bone, found a small pocket of pus, which, had he not drained it, and dealt with the bone antiseptically, might soon have cost the boy his leg or his life.

The question of the general provision of Listerian treatment for all who need it raises issues too large for us to deal with here. Such a measure as the Insurance Act cannot possibly meet this need. The surgical wards of our hospitals are already overcrowded, and the demand for beds will be greater than ever when the Insurance Act gets under way. The public dees not in the least realise what Listerism is worth, nor what are its demands. No palace is built to provide the kind of apartment which the modern surgeon desires for his work, and to which he and his patient are entitled. The social problems here raised cannot but be solved before many decades are over.

The Application of Listerism for the Protection of Motherhood

We have left to the last what will one day, and that not very remotely, be the principal application of Listerism—namely, its protection of motherhood. The destruction of maternal life in lying-in hospitals attracted the attention of Oliver Wendell Holmes in America, and of Semmelweis in Vienna, in the first half of the nineteenth century. They both received the customary treatment of medical reformers who are before their time. Not until late in the 'sixties did Pasteur discover that the too familiar *streptococcus* is the great enemy of motherhood. The epidemics it caused used to sweep away the population of the Paris Maternity Hospital like a plague, and women who had to enter it bade farewell to life; and the old reputation which the old maternity hospitals so dreadfully earned still interferes with their usefulness, even today. But Listerism has mastered the *streptococcus*. The records of such a hospital as Queen Charlotte's, in London, or the Rotunda, in Dublin, will nowadays go on for years without the occurrence of a septic case.

But there are plenty outside their walls, and will be, so long as not half the nation's cases of maternity are attended by those who are qualified in the practice of Listerism. The wards of the special hospitals for women, throughout the land, are filled with the women who have *not* received skilful Listerian attention during childbirth, and who are now upon the hands of the doctors for the rest of their days; and these are the survivors, for many mothers are infected and die every year, just as if Pasteur and Lister had never been born.

The Call for a Vital Memorial to a Champion of Life

Local and national memorials to Lord Lister are now proposed. Surely our memorial to this champion of life should take a more vital form than any dead statue! For such a one as Lister, and for such a work as his, we need a living memorial, and one which shall live as long as his work is worth remembering, which will be as long as the human race survives. As we shall later see, the uses to which Listerism is now put in surgery will ere long almost wholly pass; even the Listerian knife will be too crude and cruel an instrument. But no development of medical skill, no extirpation of the tuberculous and other diseases for which the knife is now so continually required, can ever remove the sacred and supreme needs of motherhood. Let us therefore have, as our national memorial to this champion of life, a Listerian Order of living men and women, expert and surgically clean to their finger-tips, ready to apply the principles of aseptic surgery in every birth-room in the land, so that, to the latest hour, Lord Lister may be called in as a consultant for the case of every mother and every baby of the nation which gave him to the world. Then, indeed, it may be said of him in fuller measure than even today, that he, being dead, yet healeth; and when secular changes have returned these islands, with their statues, to the waves from which they were raised, this undying and far-spread Order will carry the name and the service of Joseph Lister to the mothers of nations yet unborn.

EXAMPLES OF THE FRUITS OF PLANTS

LIME—INDEHISCENT DRY FRUIT

GOOSEBERRY—INFERIOR OR HANGING FRUIT

THORN-APPLE—FRUIT PROTECTION

MULBERRY—COLLECTIVE FRUIT

The photographs on the following pages are by Messrs. J. J. Ward and Hinkins & Son

THE FRUIT OF PLANTS

The Several Characteristics, Repellent and Attractive, That Fruits Assume to Perpetuate Their Species

THE INCREASED POPULARITY OF FRUITS

We have now to enter upon the consideration of the last aspect of the individual life of a plant which will come under our notice in these pages. We have still to pay some attention to the societies of plants as found in trees and forests, but in this chapter we shall conclude our study of the physiology of individual plant life with a brief survey of the final product of that life—namely, the fruit.

Let us, first of all, be quite clear as to the meaning of the word itself. What is a fruit? The answer depends upon the sense in which the term is used and by whom the question is put. In the popular sense, a fruit is generally understood to be some product of a plant of a more or less succulent nature, which is more or less delicious as food, and, as a rule, forms a covering enclosing seeds. This meaning would include such plant products as apples, oranges, peaches, pears, lemons, cherries, grapes, and a host of others of a similar nature. In a somewhat more limited sense, however, a fruit means the reproductive product of a tree or any other plant—that is to say, the seed of the plant or any product of a plant which contains the seed. In this sense the word covers such products of plant life as wheat, oats, quinces, acorns, melons, as well as some of those in the former list.

Even botanists use the word to convey slightly different significations, but in the science of botany the fruit is usually taken to mean the seed of a plant or the mature ovary, which is usually composed of two portions essentially—namely, the seed itself, and the covering around it, or pericarp. In the broadest botanical sense, the fruit should mean everything destined to undergo alteration as the result of the process of fertilisation in the flower or any part of the flowering axis. If one remembers that all these changes are for the object of producing an embryo, and preparing it to live a separate life from the parent plant, it is obvious that everything included in the structures helping to this end will constitute a portion of the fruit. Looked at in this way, the seed-case, seed-capsule, or pericarp, as it is variously termed, is only a part of the fruit, though in many cases it constitutes nearly all that there is of it, and, as will be seen, is frequently described as the fruit-seed. Having thus cleared the ground so as to understand in what various ways the term is used, we may now pass on to know some of the most common types of fruits produced by plants.

We may first note the fruits derived from the pistil, that arise either above it or below it, and are termed respectively *inferior* and *superior*. In those plants in which the seed-capsule, or pericarp, is formed from the pistil, and grows into a succulent, fleshy mass, the resulting mass of fruit is what we commonly call a *berry*. This may be either *inferior* or *superior*. Those of the bitter-sweet, deadly nightshade, barberry, and the vine are *superior* in position, while the berries of [illegible] mistletoe and the gooseberry are *inf*[illegible]

A second type of fruit is that t[illegible] we commonly refer as *stone fruit*[illegible] case it is the outer portion only [illegible] capsule, or pericarp, which has [illegible] succulent, fleshy, and often [illegible]ss, and the inner portion is, as [illegible] term implies, of a stony character. Wit[illegible] this stone lies the true seed. Most of these stone fruits, or drupes, will be found to contain one single seed in each stone, as does the cherry. There are some, however, which contain two stones, each enclosing a seed, like the buckthorn; and some even, like the elder, which contain from two to four stones, each with its seed within. In sharp distinction to these soft, succulent

types we come to those fruits usually termed *dry*. In reality it is the seed-capsule, or pericarp, which is *dry* in this type. The group is further subdivided into *Indehiscent fruits*, *Schizocarps*, and *Dehiscent fruits*. In these groups we have a number of edible products familiar to everyone. The *indehiscent dry fruit* separates from the plant with the seed inside it, and the whole product is so adapted as to aid in the dispersal of the seed inside, and to protect the embryo. Of such character are the *nuts*, which arise from pistils made up of more than a single carpel, as in the lime. Other *indehiscent* fruits are produced from a pistil made from one carpel only, then termed *achenes*, as is the strawberry. Most nuts contain only one seed, even though they arise from an ovary with several chambers, and this is because during the development in the later stages all the chambers except one disappear. That one contains the ripe seed.

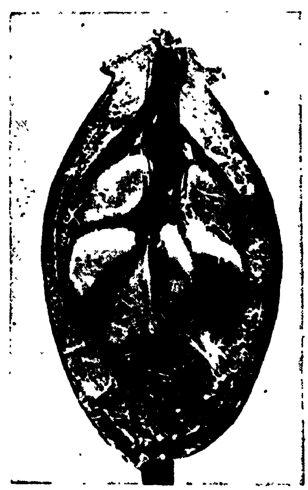
FLOWERS OF THE SYCAMORE DEVELOPING INTO FRUITS
In the flowers to the right the pistil has not developed, but in those to the left, which are older, the growth of the wings is clearly seen

The next group of dry fruits is that of the *schizocarp*, which is ...lly made up of a number of *achenes* joined together. In this type are included such fruits as the mallow, the caraway, and parsley.

Thirdly, we have the *dry dehiscent* fruits, also sometimes spoken of as capsules. They get their name from the fact that the pericarp, which is, of course, dry, as in all this type of fruit, when it is quite ripe splits and distributes the seed in a number of processes, some of which we studied in detail in connection with the subject of plant dispersal. Here, after the liberation of the seed, the pericarp, or. seed-capsule, generally remains behind, still attached to the plant. If it does not do so, it separates from the parent in pieces—that is to say, it *dehisces;* hence the name. But, whichever method is adopted, this dry pericarp has nothing further to do with the growth of the seed which has been set free from it, in contrast with that of the nuts, for example, where it has a protective function lasting for a long time, until the seed may be covered by soil.

Regarding the word fruit in the botanical sense, these dry dehiscent fruits, or capsules, are the most common fruits of all. One of the best-known examples of them is the *follicle*, which opens along one side, as in the monkshood. Another common kind is the *legume*, or *pod*, which, when ripe, splits along both sutures into two valves, as in the pea and the bean. Still other *dry dehiscent* fruits might be regarded as being more truly capsules—for instance, those of the poppy and the violet and the snapdragon. Still another kind of *dry dehiscent* fruit is that which is characteristic of the well-known "honesty," in which the walls of the carpels gradually disappear and leave a very curious appearance of a delicate framework with the seeds still sticking to it. So much for the *dry dehiscent* fruits.

AN IVORY NUT



A WILD-ROSE HIP

Both these photographs show longitudinal sections with the seeds inside

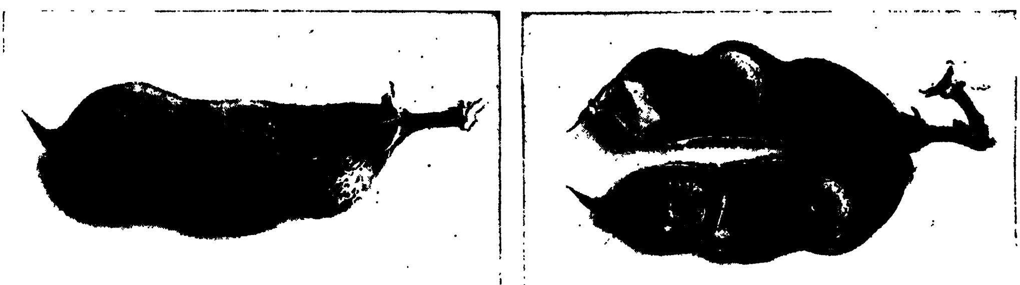
Next we may note the type of fruit termed a *collective* fruit, produced by some of the

plants in which the flowering portions grow in very close clusters, and, as the result, when the fruit is developed they are produced so close together that they fuse more or less completely into one mass. Since this really contains a number of fruits, the term *collective* fruit is applied to the whole thing. They are usually supported on one fleshy framework of a succulent nature. Well-known cases of this kind are those of the mulberry, the bread-fruit, and the pineapple.

Another kind of fruit cluster is that seen in the raspberry and many other plants, in which, however, the fruit is really better described as an aggregate

THE SEED OF THE MALLOW

produced at the earliest stages, only one of them reaches maturity, and this one, of course, is found in the ripe seed. This is the case in the silver fir, spruce fir, and pine. From the species just mentioned, it will be noticed that many of these *gymnosperms* produce cones, the cone being really a mass of scales that may be regarded as the aggregate fruit. In fact, the *gymnosperm* plants produce their fruit in many ways; but all of them have this in common—that the embryo is an extremely hardy one, and is provided by the parent plant in the aggregate fruit with many protective appliances, some of which are also obviously intended to aid in dispersal.



LUPIN PODS CLOSED SHOWING PROTECTIVE HAIRS, AND OPEN, SHOWING SEEDS WITHIN

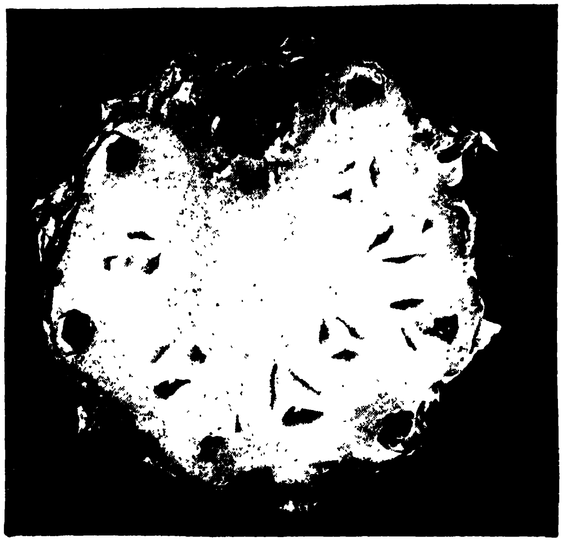
uit, because produced from single flowers. o far, in our consideration of types of uits, we have referred ıly to the class of plants nown as *angiosperms*, or ıose plants which have ıeir seeds enclosed in ıme kind of vessel. We ıust now note for a ıoment the nature of the uit in those plants whose eds have no seed-vessel ı connection with them, nd which are termed *ymnosperms*, of which all he coniferous plants are xamples.

In this group of plant ıe process of development as some peculiarities of s own which we need ot enter into here, beyond stating the ne fact that, although many embryos are

HONESTY SEEDS

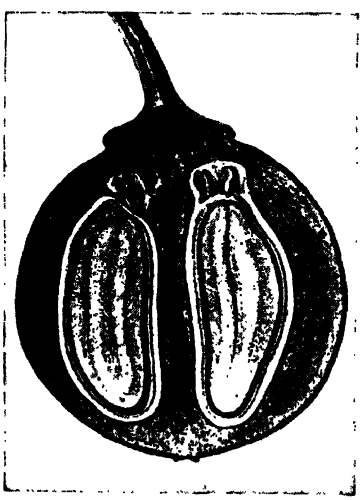
The fruit needs protection at two stages of its career. In the first place, it must be protected from destruction by animals and by severe climatic conditions while it still remains attached to the parent plant. Some of these protective arrangements we have already studied in connection with stems and leaves, and it is interesting to note here that similar special developments occur in connection with the fruit. Just as in the case of the leaf, so here we find surrounding the fruit such structures as thorns and prickles of different kinds, excellently adapted for this purpose. The capsule of the thorn-apple takes its name in this way. Some of the

pines have the scales of their cones terminating in very sharp spines. A peculiar protective arrangement is that in some of the mimosas, where the pods are so crowded together that they form a double row of spines. All these protections apply only until the time that the seed is fully ripened. After that time, when the fruit breaks up into its different parts, they no longer give protection, but they may still aid as a means of dispersal. In other cases it would be a distinct disadvantage to the seed to be so protected afterwards—for example, in those which depend upon the agency of birds for their dispersal. In this case the former protective organs are generally separated from the seed when ripe, or else the fruit itself, as we studied in a previous chapter, is of a succulent nature externally.



TRANSVERSE SECTION OF A PINEAPPLE
The fruits are supported on the fleshy framework here showr.

An interesting kind of fruit is that seen in the rose, where it is known as a *hip*. This fruit, it will be remembered, remains attached to the rose-tree, or plant, even after it is ripe. Within it, of course, are contained a number of small, hard fruits, like diminutive nuts. Their covering, however, forms an attractive food to various kinds of birds, especially blackbirds; and in eating this the birds also devour the seeds themselves, which, however, are not damaged by any process of digestion, and, of course, pass out with the droppings of the birds in various places. Curiously enough, the rose plant, and others of its type, are afforded protection from mice and other creatures which would destroy the whole fruit by gnawing it, owing to the sharp prickles which they possess on their stems or branches; and the same means of protection is very well seen for the fruit of the blackberry and the gorse, whose branches bearing the fruit are extremely spinous.



LONGITUDINAL SECTION OF BUCKTHORN FRUIT

One would not think at first sight that the pod of such a plant as the pea was very well protected, and possibly in some respects it is not. A second thought, however, will show us that the long, delicate stalk which bears the pod is in itself a protection, because it makes the fruit rather more difficult of access. The seeds, in this case, are so very nutritious, and hence so much sought after, that they would have little chance of escape were it not for this device. The same thing applies to the long stalk of a cherry with its fruit at the end. This stalk does undoubtedly offer considerable difficulty to the attacks of earwigs and other enemies, as may be gathered from the manner in which the cherry is devoured should it happen to fall to the ground.

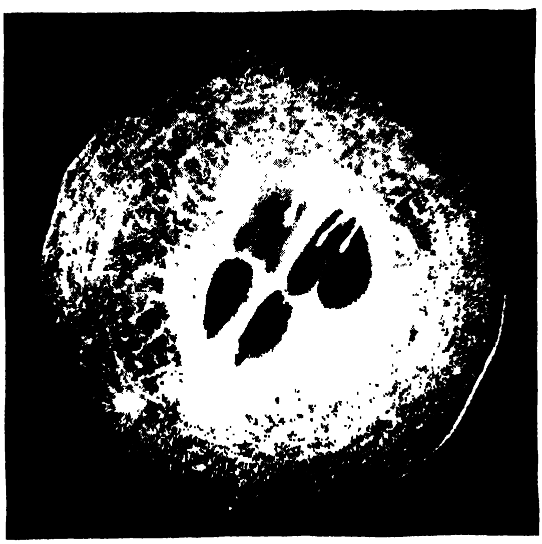
One other means of protection against the ravages of animals must be mentioned. Although the fruits themselves, or parts of them, afford delicious food material for animals, it is, nevertheless, true that the edible portion of the fruit is not attractive or palatable until the seeds are ripe, when, of course, they can be separated from the other parent structures without risk. This is excellently seen in such fruits as the grape, the cherry, the orange, the plum, and so forth. As long as the covering of these seeds is bitter, the seeds themselves are adequately protected. Later on, when the succulent portion has become sweet and nutritious, the contained seeds have reached ripeness, and are ready for distribution by animals. Perhaps the best example of all

of such a case is that of the walnut, in which the seed itself, which is, of course, within the nut, is surrounded by an extremely disagreeably tasting covering, that, as far as we are aware, offers no attractions at that stage to any animal.

In still other cases protection is afforded to the fruit by various substances of a sticky, strong-smelling, or resinous nature, rather characteristic of the pines. It is this material which sticks so pertinaciously to a knife if an attempt be made to cut across the young cone. It is only when the cone is ripe that birds can gain access to the seeds that then are ready to be dispersed. Many plants produce some sticky material of this kind in one or other of their structures. In the common hop there are glands on the scales which do the same thing, and the same is true of the hemp. In neither of these plants is the fruit interfered with until ripe, even by sparrows.

FURZE PODS ON A SPINY BRANCH

Next, as to the protection of the fruit against climatic agencies. The two things to be most dreaded are too much moisture or too little. Seeds contained in the berries and stones are not so much exposed to these factors, nor are those produced within capsules. But in those fruits of the *dehiscent* type, which open before the fruit is scattered, protective arrangements against rain gaining access to the fruit are found. In a great many cases it is found that these capsules, or valves, open only when the weather is dry, closing up when the atmosphere becomes moist. This protection to ***dry dehiscent*** fruits only exists as long as the fruit remains on the parent plant, but in the nuts it persists, of course, for very much longer. Here the seed-covering and the seed go together for, it may be, a very long period, the shell of the nut protecting its kernel all the time, and in some cases even assisting it to germinate.

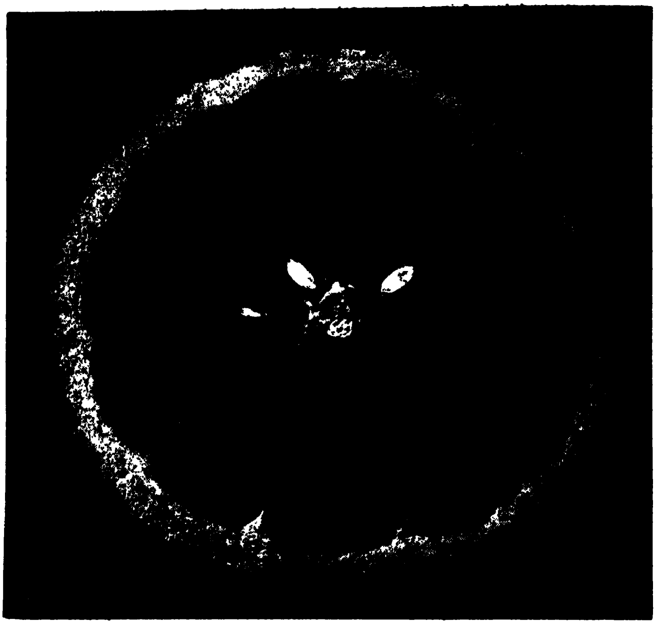


SECTION OF A CUCUMBER, SHOWING SEEDS ATTACHED TO ITS INTERNAL WALLS

Lastly, in this connection, it may be interesting to note the extraordinary variation in size of the portion of the fruit which surrounds the embryo at the time when it is separated from the parent plant. "The seed of the terrestrial orchid *Gymnadenia conopsea* is one millimetre in length, and weighs ·008 gram; that of the cocoanut palm, 11-14 cm., and weighs 800-1100 grams. The wind bent-grass (*Apera spicaventi*) has a grain 1·2 mm. long, ·3 mm. broad, and weighs ·05 gram; the fruit of the Seychelles palm (***Lodoicea sechellarum***) measures 32 cm. by 18-25 cm. by 22 cm., and weighs 4200-4800 grams. The largest fruits are produced by the ***cucurbitaceæ***. In a suitable soil gourds attain a diameter of half a metre, whilst fruits of the melon-pumpkin (***Cucurbita maxima***) have a greatest diameter of over a metre, and a weight of 75-100 kilograms. The fruits of the bottle-gourd (***lagenaria***) attain, under favourable circumstances, a diameter of 30 cm., and a length of a metre and a half."

Let us now very briefly study the structure of a few typical fruits, selecting our examples from those in common use in our households, and of value from a dietetic point of view, in order that we may apply what we have learned in this and previous chapters in a practical manner. Let the reader procure for himself, or herself, a lemon, selecting as large a one as is obtain-

able, and proceed to note as many as possible of the following points. At the base of the fruit there will be observed the remains of the calyx, with a little lump, on it which indicates the position once occupied by the stigma. The external rind is seen to have a pitted surface, the significance of which has been explained.



TRANSVERSE SECTION OF A LEMON

With a knife now make a transverse section of a whole lemon towards the end of the fruit where the stigma was. Such a section will enable one to observe quite a number of points, amongst which are the following—There is a somewhat thick skin, of a pale yellow or lemon colour externally, but quite white on the inside. The whole fruit itself is divided into a number of parts, in the shape of wedges, often termed familiarly "quarters" in this and the orange. These sections, or divisions, are really the fully matured cells of the ovary. Each of them shows a thin skin which is the division, or partition wall, between the cells of the ovary. In the middle of the transverse section there is a central column of a white colour and a pithy texture. In one or other part of the section there will probably be seen some seeds enclosed in the fruit, whose position and method of fixation should be observed.

With a magnifying glass some further points of interest may be noticed, especially on the skin, or rind, where there are little round cavities which contain an oil—the oil of lemon. This is the substance to which the fruit owes its peculiar smell and taste, and which, if squirted out into the eye, makes itself painfully obvious. The magnifying glass will also show that the pulp of the lemon is made up of a number of tubes, and these tubes are full of juice. Right in the middle of the fruit on a transverse section will be seen dot-like structures, the cut ends of fibro-vascular bundles. It was along these, it will be remembered, that the sap of the plant was carried to the fruit-cells, enabling the latter to develop. These various points may be the better understood by a reference to the diagram in this chapter.

Next secure a specimen of the common tomato, selecting preferably a small one. This well-known edible fruit is a typical example of the grouping of berries. It will probably exhibit the persistent calyx, with its peduncle. The thick skin, or epidermis, can be readily peeled off, and the wall of the ovary seen, as well as the partitions between the cells of the latter. Within these the contents of each cell are obvious, and the attachment of the seeds to the placentas can be easily seen. Each seed, it will be observed, has a distinctly slippery covering.

A common bean-pod, taken next, will serve excellently as a type of the fruit of a legume. A single glance will show on it the stigma, the style, the ovary, the calyx, and the peduncle. Within it may be seen the seeds at their stages of development, each lying in its own receptacle, divided by a solid wall from the neighbouring one. The beans themselves are attached to the placentas by a stalk, with the function of which we are already familiar. If, instead of a young, fresh bean, an old, dry one from last year's crop be taken, the observer will notice where the splitting, or the *dehiscence*, of the pod took place.

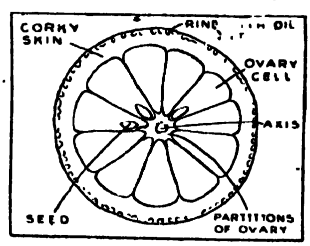
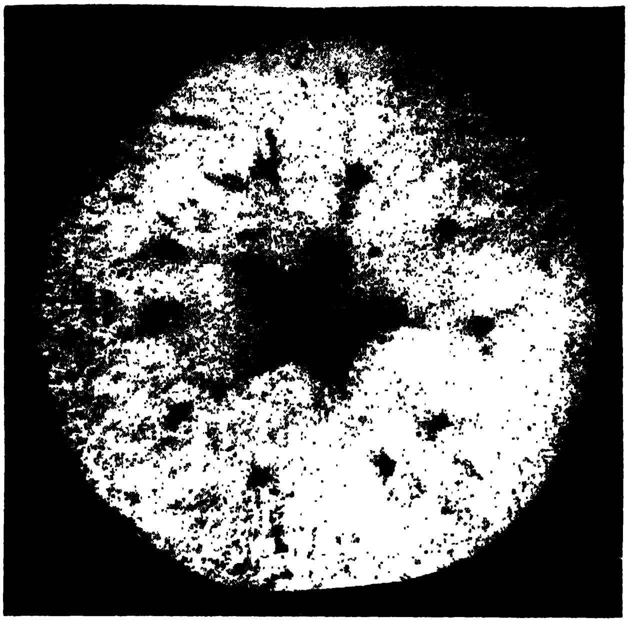


DIAGRAM OF SECTION OF A LEMON

To study a common *achène*, all that is necessary is to examine with a magnifying

glass the fruit of the common dock. This, it will be found, is enclosed in three membranes, which are the dried sepals. It will be further noticed that this is an example of a fruit that remains attached to the parent for some time after it is ripe.

Next may be examined an ordinary apple or pear, which presents still further points of note. In this case the carpels arise in a whorl from the end of the axis, where there is an excavated receptacle. The margins of the carpels fold inwards, and ultimately fuse together so as to form an ovary divided into a number of chambers, which is hence termed *multilocular*. This ovary fills the entire cavity of the receptacle, and, as a matter of fact, is completely fused with the inner wall of that cavity. The ovules, or embryonic seeds, are carried on the infolded margins of each carpel—that is to say, on the walls of the several compartments of the multilocular ovary. The same arrangement is found in the now somewhat uncommon medlar.



TRANSVERSE SECTION OF AN APPLE

So much for a fruit looked at as a botanical product. In such space as remains to us we turn our attention to the subject of fruit as a whole, noting in connection therewith some points of interest.

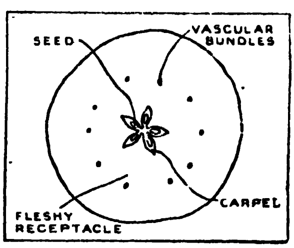


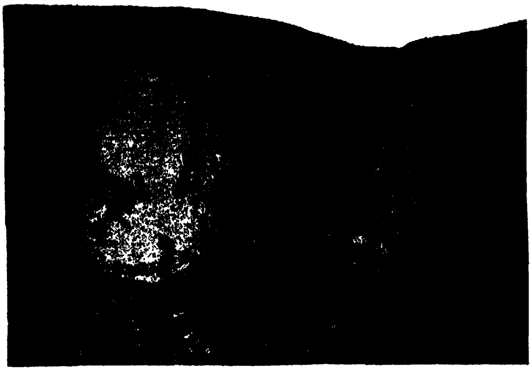
DIAGRAM OF SECTION OF AN APPLE

The dietetic value of fruit in the food of a nation has been wonderfully more appreciated in our own country in comparatively recent years than it was formerly, possibly because of the vastly increased means of communication between ourselves and foreign lands, and the trading facilities which have resulted in placing enormous quantities of foreign-grown fruit upon the home market at prices that have brought it within the reach of practically everybody. One of the most curious results of this increased trading facility is that it is possible to-day to purchase the very best Tasmanian or Californian apples in any good British fruiterer's shop at a price not any more, and often less, than that for which a similar quality of home-grown apples can be purchased. This is not the place to discuss how that should have happened, or why we cannot grow our own good fruit for our own market to greater advantage; we merely note the fact.

Still more noticeable, perhaps, is the manner in which certain fruits which cannot be grown to advantage in our own climate have in recent years taken a place as an almost indispensable article of diet in the food supply of our people. Probably most of the readers of these pages will recollect the time when the banana was a comparative rarity in our shops and an absentee from our streets. Today it can be bought for a copper anywhere and everywhere in this country, and the total consumption is an immensely vast one. Even the very poorest inhabitants have it brought to their own doors, and find in it a fruit which is at once nourishing, sustaining, and cheap. No better example than this of the banana could be taken to illustrate the value of fruit in general as food, and we may therefore select it to note some special points.

The chief sources of supply of the quantities of this fruit which reach Great Britain are Jamaica, other West Indian islands, and parts of Central America. The cultivated plant itself, curiously enough, is without seeds, and the new plants are

produced by the process of propagating cuttings. Two fruits are sold under the general term of banana—namely, the true banana and a variety which is the plantain. The banana-tree in Jamaica grows

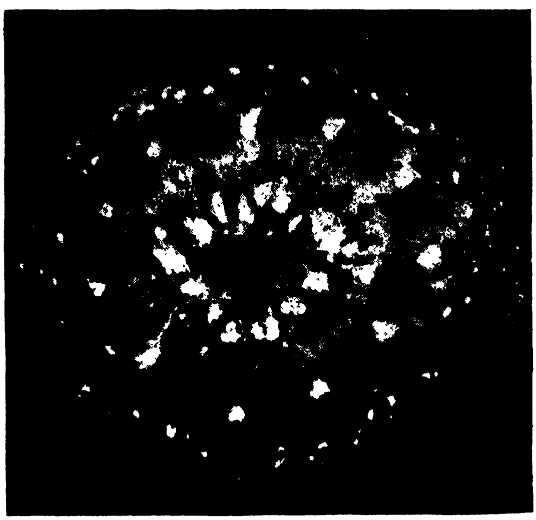


THE OIL-GLANDS OF ORANGE-PEEL
It is the bursting of these glands which produces the fine sprays of bitter oil when peeling an orange.

to a height of about 12 feet, being almost twice as high as that in the Canary Islands. The root-stems of the plant produce leaves whose petioles form a hollow stem and blade, which are 6 feet long, or more, spread out. The stems which carry the bunches of fruit shoot straight up from among the roots, and show amongst the leaves. As may be seen in any large fruiterer's shop, the banana grows in huge clusters of fruit, any one of which may weigh as much as half a hundredweight. The yellow appearance of the skin, as well as the black patches which are frequently present, is produced by the process of artificial ripening taking place between the time of the gathering of the fruit and its reaching our market. When gathered it is perfectly green. Although an important article of food in countries where it is produced, it is not highly esteemed there among the richer classes, and, in fact, in Jamaica it is often given to cattle. That is nothing against the banana as a fruit. The present writer has seen the most magnificent peaches, which in this country would command a high price, being similarly given to pigs as food in New Zealand, simply because they were grown in such abundance, and all ripening at the same time, that there was no other way of disposing of them.

It may be noted in passing that the banana group of plants, all of which are naturally tropical, have irregular flowers, in which the inferior ovary is, as a rule, divided into three compartments. The group includes, besides the banana proper, the plantain, ginger, and arrowroot, so that its importance from the food point of view is abundantly obvious. All such plants require high temperature in order to bring them to perfection. In all probability the yield of fruit per acre from a banana plantation is greater than that of any other plant used for the food of man; and since the expense of cultivation and labour in connection with its production is very slight, it is no wonder that with the increasing consumption at the present time large fortunes are being made in the industry. When it is remembered that the importation of the banana into the United States is also immense, some idea may be gathered of the amount of fruit produced. Some five or six years ago it was computed that the importation into this country of the banana fruit was something over one million bunches annually, and probably that figure is considerably exceeded now. The average price of a bunch in Jamaica varies from sixpence to two shillings, whereas in London the same bunch costs from three shillings to nine shillings.

Another fruit in connection with which



THE ROUND SCAR AT THE BASE OF AN ORANGE
This section is where the fruit is separated from the stalk, and shows the two rings of fibro-vascular bundles.

we may note a few points, and one that, like the banana, has rapidly increased in popularity and consumption in this country, is the date. It belongs to the order of the

palms (*Palmaceæ*), an order that includes also the cocoanut-palm. In the plants of this group the leaves form a very characteristic large tuft at the end of a long, cylindrical stem. Not more than three seeds are produced by a flower. The date-palm is the chief product of the oases of the African and other Old World deserts. The fruit is carried on bunches, which have a single stem with a number of slender twigs, to which the fruit is attached, and each bunch may consist of from ten to thirty pounds weight of fruit. The dates themselves do not all ripen on the same bunch at the same time, and for this reason the practice obtains, in the best varieties, of picking by hand those on the bunch that ripen first, and shipping them at once in order to obtain a higher price. When the majority of the fruit on the bunch has ripened, the whole bunch is cut off and hung up to ripen; and this it does in the course of a few weeks. The best varieties come from the Sahara Desert, being exported largely from Algiers. When properly packed the fruit will keep for years without deterioration. (See page 3553.)

TRANSVERSE SECTION OF TOMATO, SHOWING SEED-CHAMBERS AND PLACENTAS

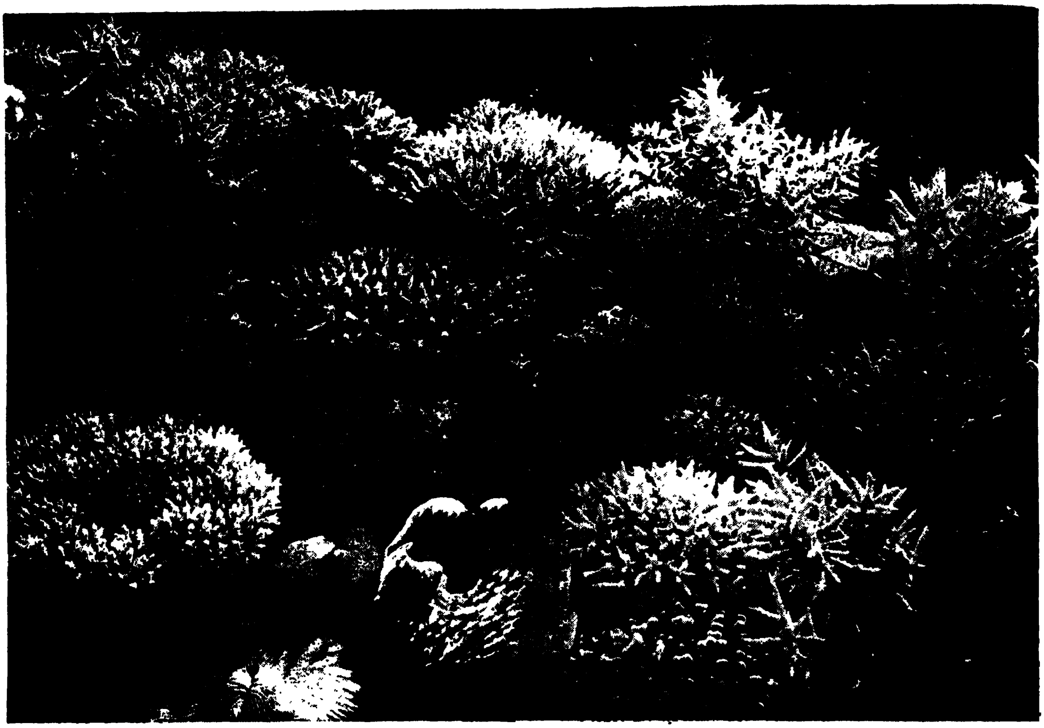
In conclusion, we may note a few points in connection with that universally popular fruit the orange, which is not only important as an article of diet in the form of the fruit itself, but supplies such immense numbers for the manufacture of that essentially British item of the breakfast-table, marmalade. Marmalade was originally made from the fruit of the quince, but is now manufactured from orange-

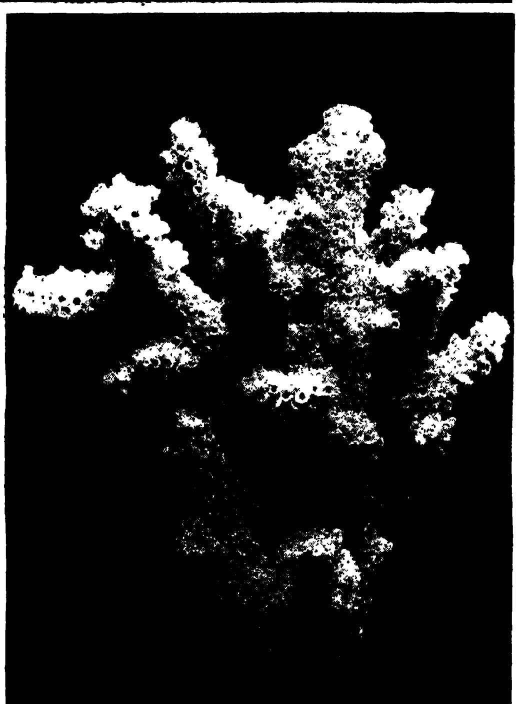
LONGITUDINAL SECTION OF TOMATO, SHOWING HOW THE SEEDS ARE ATTACHED TO THE PLACENTAS

pulp—or it should be. The best marmalade is made from the use of both bitter and sweet oranges, along with lemons. Both of these fruits, which are perhaps the most easily marketed of all, come from the coast of the Mediterranean, China, the Azores, Mexico, Australia, and California. The oranges are gathered before they are quite ripe, when they are fully formed and the greenish colour is just turning into yellow. They are wrapped in paper or in the husk of Indian corn, and packed in boxes that admit plenty of air.

The orange-tree itself lives to the good old age of over a hundred years, during a large portion of which time it may bear some thousands of oranges annually. It has a very similar distribution to that of the lemon-tree, and cannot flourish in the presence of frost. The fresh fruit eaten in this country comes chiefly from the Azores, Spain, Portugal, Sicily, Malta, Palestine, and the West Indies.

It is not generally known that the orange was originally a native of China, the fruit being introduced into Europe by the Portuguese in the sixteenth century. The best kind in our markets comes from St. Michael's, in the Azores—that is, the thin-skinned, pale, juicy orange with but very few pips. The prolificness of the finest orange-trees is such that a fully matured tree may carry twelve thousand oranges in one year.





A FEW OF THE MANY VARIETIES OF CORAL NOW BEING MADE IN SHALLOW SEAS
The photographs on these pages are by F. Martin Duncan, Saville-Kent, W. B. and S. C. Johnson, and others.

A FINAL SURVEY OF THE SEA

The Curious Life-Stories of Some of the Lesser Folk of the Ocean

STRANGE HISTORY IN A PEARL NECKLACE

In concluding our examination of life in the sea, we must all realise that we have to employ a small net of large mesh, and that many interesting families of the lesser lives of ocean escape us. We cannot, however, quit the deep without a final haul; and in order that this shall preserve some relation to that which has gone before, it may be of interest to refer again for a moment to pages 293-4 of the present work, in which we have a hint of the bridge by which the gulf between the vertebrates and the invertebrates is spanned. The lampreys and their allies occupy that middle kingdom in which life in the larvæ begins seemingly with the promise of a backbone—a promise which is never fulfilled. The tunicates or ascidians, popularly known as sea-squirts, though as unlike the lancelet as a tadpole is unlike the adult frog, are held to be more related to the lancelet than is the latter to the lamprey, which it so much more closely resembles.

There is, however, this vital distinction—that whereas throughout life the lancelet preserves the notochord, the tunicates, generally speaking, have the notochord only during the larval stage. In the latter condition all the tunicates possess the notochord—that fibro-cellular rod of the embryo of vertebrates to which the spinal column succeeds. But, except in two or three genera, the passage from the larval to the adult condition is accompanied by the disappearance of this prophecy of a backbone. Practically all the tunicates which undergo this metamorphosis sacrifice their mobility with their vertebrate characteristics; they attach themselves by the forepart to weeds, or to one another, and drift, absorbing water and nutriment by one orifice and expelling water by a second. One order of tunicates, the Appendicularidæ, retain the rudimentary vertebrate suggestion; they remain free swimmers to the end of the chapter; and, failing any more feasible explanation, they must be regarded as having, like the axolotl among amphibians, become permanent larvæ, as it were, with the adult stage of their existence eliminated.

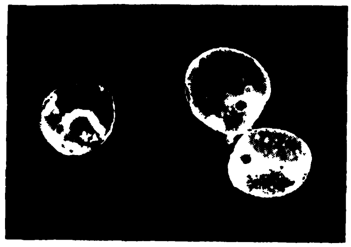
The method of reproduction by these lowly creatures is complex and interesting. Two sexes are combined in every individual tunicate, but reproduction differs from generation to generation. Take the sub-order salpæ, a group of beautiful, transparent tunicates. These are found in two forms, as solitary salpæ, or as colonies—the famous colonies of chain-salpæ, so called from their fashion of forming themselves into a long chain made up of salpa linked to salpa. Now, the solitary salpa gives birth, by budding, to the chain-salpa, while from each unit of the colony of chain-salpæ a solitary salpa is born, from an egg carried within the body of each parent form. So early do the eggs develop that a solitary salpa gives rise to the germ cells of the next solitary form, which cells will develop in the body of the chain-salpa to which the solitary species gives birth by budding; and the cells of the embryo of the next generation but one are actually visible before the development of the stolon from which the chain-salpa is to arise by budding.

We touch a little lower level in the scale of vestigial or rudimentary vertebrate life in reaching the Hemichordata, of which the Balanoglossus is the typical representative. By some writers this so-called vertebrate-like worm is claimed as a worm-like vertebrate, but it is neither the one nor the other. The notochord, retained throughout life in the long proboscis and the dorsal nerve-like chord running along the back, may be either prophecy or relic; but while they proclaim the affinity of the

Balanoglossus with the true vertebrates, larval conditions seem clearly to indicate a genetic relationship on the one hand to the starfishes and sea-urchins, and on the other to certain deep-sea worms.

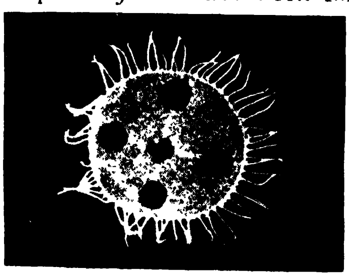
In view of extraordinary relationships such as these, who will dare attempt to fix an arbitrary boundary-line between the highest forms of life and the lowest? Such boundaries do not exist. The Balanoglossus and one or two kindred genera of protochordates constitute a link of the highest importance in the chain of animate creation, showing how almost imperceptibly vertebrate characteristics merge in invertebrate.

We must now turn our attention to sea-dwelling examples proper of the invertebrates; but instead of tracing the line downwards, we may take them in an ascending scale, beginning with the lower and working towards the higher forms. As every student will notice, some of the forms referred to in this section are to be found in all waters—not in the sea alone.



NOCTILUCA, WHICH LIGHTS UP THE SURFACE OF THE SEA

Lowest of all we find the protozoa, or animalcules, in which life and instinct reside within a speck of protoplasm, consisting of a single cell with a nucleus; a tiny organism which feeds and breathes and has the power of motion, and multiplies by a process of fission, or dividing in two. The protozoa, while they swarm in every sea and at almost every depth that has been sounded in the icy seas of the Poles and in the heated waters of the equator, teem in the soil, in the water that we drink, in the food that we eat. Berlin is built upon their multitudinous remains. The soil there was unstable through the presence of uncountable myriads of living examples, which multiply in this fashion: one becomes two, two become four, four become eight, eight become sixteen, and so on, till, in the course of twenty-four hours, the descendants of a single individual number a million, and in four days about 140 billions, which number represents two cubic feet of soil. Some of these animalculæ fertilise the soil; others light the seas at night with incomparable phosphorescent glory. The minute nightlight animalcule (Noctiluca miliaris), when it flashes its microscopic lamps along the watery sea-path down which it whips its way, achieves a miracle that man with all his art and cunning cannot match; and the animalcules which fashion shells out of sea-water have done more for the earth than man himself! So small as to need the aid of a microscope for their identification, these insignificant organisms have had an enormous share in building up the solid crust of earth.



THE MEDUSA, OR JELLY-FISH, STAGE OF THE OBELIA

It is simply the shells of animalculæ that have lain long æons dead that form the chalk and limestones of the world. The Pyramids, mightiest work of the hands of men, are fashioned from stone composed in the main of the shells of the Nummulina. The deposits of these shells, converted in places into stone *thousands of feet in thickness*, reach from the Alps to the Carpathians. "The deposits are in full force in the north of Africa, as in Algeria or Morocco. They have been traced from Egypt into Asia Minor, and across Persia by Bagdad to the mouths of the Indus. They occur also not only in Cutch, but in the mountain ranges which separate Scinde from Persia and form the passes leading to Cabul; and they have been followed farther eastwards into India, as far as Eastern Bengal and the frontiers of China."

The birth of these minute shelled animalcules continues today in our seas, beneath whose waters they are hourly dying and forming deposits of ooze which in time to come will raise the level of sea-beds to form new lands and make islands continents and continents islands. Not all these protozoa are microscopic; some such as the nummulites may attain a size of half-a-crown; others, such as the Fusulina, reach half an inch in length. But wherever there is limestone, there ponderous volumes of life that has been are written.

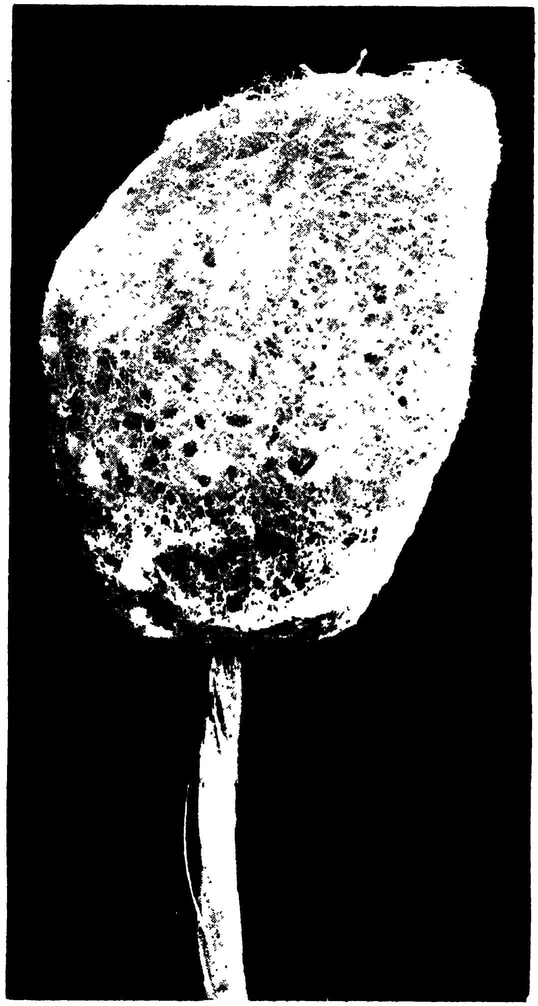
Not all the protozoa are thus helpful to man. Some, indeed, are among the deadliest scourges of human and animal life. These, parasitic in habit, cause such fell complaints as sleeping-sickness and diseases fatal to cattle and horses in tropical lands.

agellata, by their curious action in water, l Priestley to the discovery of oxygen; but the same great group we find the deadly ypanosomes, which are the most terrible emy of human life in Uganda.

At another point of this chart of life we ve another ill-famed group, the Sporozoa, iich reproduce by means of minute spores, d are responsible for a number of deadly ılarial diseases. The company of protozoa

THE VENUS FLOWER-BASKET

'ast and varied, and not to be treated in ail in this place. We pass to a higher ise of life in the Metazoa, in which, in ce of one-celled animals, we have forms vhich many cells are present. The lowest these are the sponges. Not everyone ognises that that indispensable Comnion of the Bath, the sponge, is the skele- of an animal, but such, of course, is the case. Sponges are merely many-celled animals, and the common sponge is the horny abiding place of a colony of such animals. The honeycomb tubes are the passages by which water containing oxygen and food is drawn into the central cavity, and expelled after its valuable properties have been extracted. This constant flow of water, upon which the life of the sponge depends, is brought about by the lashing of



THE GLASS ROPE SPONGE

flagella attached to collar-cells much in the same fashion adopted by certain of the animalcules living in colonies, from which, it is conjectured, the sponges have descended.

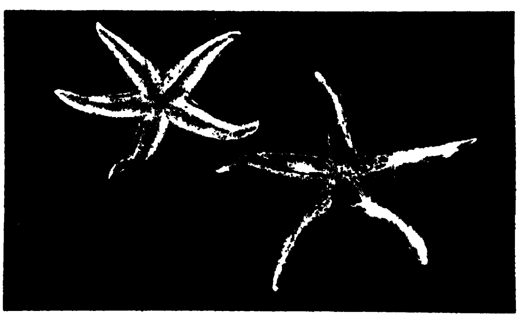
It is needless to add that sponges are many in groups and formation. Some are fleshy, some are calcareous—that is, with a skeleton built up of lime—some have siliceous

spicules, some have spicules which take the form of simple rods or needles, while others have the skeleton chiefly composed of horny fibres. One of the calcareous sponges, Sycandra raphansus, which is common in British waters, is a free swimmer in the larval stage. Sponges abound in the chalk, and the flints of the Upper Chalk are often deposited around such sponges, from the spicules of which the flints are supposed to have derived their siliceous material. It seems difficult to believe, but sponges are the enemies of our coasts. One sponge (Cliona) is a redoubtable borer, and tunnels into limestone coasts and conduces in course of time to serious erosion. The lover of oysters detests this sponge, as it tunnels the shell of the bivalve as unerringly as the whelk.

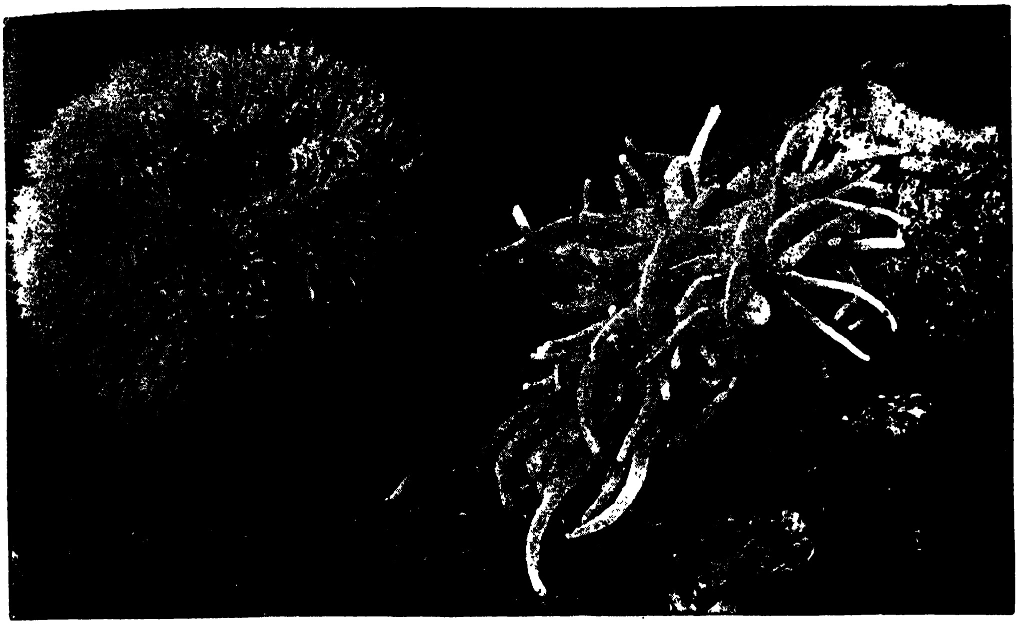

A BRANCHING SPONGE

To call a man a jellyfish is to impute such flabbiness and futility as a veritable jellyfish itself would resent. But once all life was fashioned upon lines such as are followed by the jellyfish and their allies, the corals and sea-anemones. These constitute the great sub-kingdom known as cœlenterata. These animals lack the closed alimentary canal of other animals —the internal space corresponding with the entire body cavity. The cœlenterate has no separate digestive track, no closed blood vascular system, and no specialised respiratory system. Internally there is one system of cavities, all in open communication one with another, and occupying almost every corner of the body. The food is taken in by way of a mouth which is a mere slit on the ventral side of the body. It is digested in a stomach which communicates by an open end with a funnel-like cavity, from which canals arise running in various directions. Into this funnel the partly digested food, mixed with water, is drawn. The indigestible food is ejected with mucus from the mouth, much as pellets are ejected from the throats of birds of prey.

Various methods of locomotion are adopted by free-swimming jellyfish—by the rowing motion of tentacles or arms, by the alternate folding and unfolding of the body, and so forth. The comb-jellies have no stinging apparatus, but possess upon the tentacles a series of knobs covered with an adhesive substance, by means of which prey is snatched and held. In this group we find the famous Venus' girdle. The jellyfish of this group, which are known as the Ctenophora, undergo a metamorphosis, and in one species at least the larvæ become sexually mature, and before reaching the adult stage are capable of reproduction. The larvæ of these larvæ, however, do not, rep oduce their kind until they have attained sexual maturity. In the Cnidaria, or stinging cœlenterata, which comprise the sea-anemones, corals, and the stinging jellyfish, as well as the little hydra of our ponds, the adhesive knobs of the Ctenophora are replaced by a complicated series


UNDER AND UPPER SIDES OF STARFISH


A JELLYFISH AWAITING THE TIDE



THE BEAUTIFUL DAHLIA AND SNAKE-LOCKED ANEMONES

of poisoned barbs. These are contained in tentacles, which normally are coiled up within a tube. When shot forth, the barbed hooks inflict a wound into which a violent irritant poison is almost simultaneously injected. In the Cnidaria we find another example of alternation of generations. Some fix themselves to weeds or stones at the bottom of the water, where food supplies must necessarily be limited. If the eggs of these stationary animals developed where they were deposited, general starvation would be the outcome. These stocks, as they are called, produce jellyfish, which become detached and swim away to scatter eggs. From the eggs result more stocks, and from these, again, more eggs result.

THE BEADLET SEA-ANEMONE, CLOSED AND OPEN

Some reference to the life of the jellyfish will be found upon page 294. Here it may be added that while the swimming-bells which rise from the stocks to seek food, and distribute their eggs, are the highest type of the stinging group, so the Siphonophora are the highest type of swimming-bells. These are really extraordiary colonies of swimming-bells, some of which row the whole along, while others capture food for the colony, others act as guards, and yet a further section of the colony produce the eggs.

Here is a description of one such colony of Physophora. It consists of a long tube or central axis, surmounted by an individual which is nothing but an air-vesicle for holding the colony in an upright or sloping position in the water. Below the air-vesicle come two rows of bells, which, by their contractions, bring about the movement of the whole colony. These rowing-bells force the water out of their cavities, and thus propel the entire colony. Below these, again, comes a circle of extremely mobile tentacles, which may perhaps be the tentacles of vanished bells. Among these tentacles are hollow structures, open at the end, which are the feeding-bells, now reduced to sucking-tubes or stomachs, each of which endeavours to seize and digest for itself whatever, in the shape of food—chiefly small crustaceans—is brought to it by the long capturing filaments and their branches, armed with stinging organs. The colourless nutritive fluid

prepared by these two stomachs serves for the nourishment of the whole colony, and is carried to the various parts through the axial tube. The reproductive or egg-bearing bells of Physophora appear like clusters of grapes; in other genera, they are capsules; in others, again, they may be actual swimming-bells, which become detached and lead an independent life. This fact is of importance in helping us to understand that this complicated organism is not a single animal, but a stock or colony. Of this there is evidence in the swimming-bells, as well as in the two, three, four, or more sucking-tubes with distinct mouths and stomachs.

And, lastly, we have the reproduction brought about by detached jellyfish-like individuals. All the parts of the organism form a whole in a physiological sense; they belong to one life, and many are so modified as no longer to appear as individuals. But, on the other hand, some of them are fairly independent; and when they take the form of medusæ they are so highly developed that their individuality is at once manifest. We must therefore regard a siphonophore as a colony of highly modified individuals, which, owing to the fact that these differ greatly in form and function, constitute what is termed a polymorphous colony.

We cannot follow the subject further, except to mention that certain anemone-like growths discovered upon the shells of gastropods inhabited by hermit-crabs are often not anemones at all, but the stock from which will arise free-swimming jellyfish. In such stock there are never more than two forms of individuals—the nutritive and the reproductive. The former, with their long tentacles and mouths, feed the reproductive with fluid nourishment, transmitted by way of canals, the reproductive individual having no mouth. To the danger from the stings of the more virulent of jellyfish, there is no need to allude, except to quote an expert opinion to the effect that many cases of drowning round our coasts may be attributable to sudden loss of power caused by the shock of swift and powerful injury caused by jellyfish.

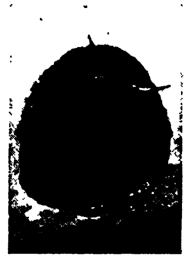
As the life-story of corals is fully treated upon page 3666, we may pass over this phase of life, and glance for a moment at the sea anemones, among which are included some of the most exquisite forms of sea-life. To the casual eye they appear to be of vegetable origin, but Aristotle, two thousand years ago, discovered their true nature. Unlike the coral, the anemone does not secrete any calcareous skeleton either inside or out, but is enclosed in a tough, leathery skin, which is capable of considerable contraction and alteration of shape. Most species employ a foot-disc as a means of locomotion and attachment, securing themselves to the shells of animals more gifted as travellers, which can carry them to sites more favourable to the collection of food. Sea-anemones are extremely voracious, absorbing surprisingly large items of food—large pieces of flesh, and even mussels and oysters. The bulk of the anemones are equipped with long tentacles, which are hollow, with a minute aperture at the tip, from which, at the moment that the animal seizes its prey, the water contained in the body cavity is expelled. In the deep-sea examples, however, which would find capture in the ordinary fashion by tentacles a difficult business, the tentacles are modified to such an extent that water containing organic matter can be drawn through the larger opening of each tentacle. One genus, Liponema, has the body-wall perforated by hundreds of openings leading into the digestive cavity, and corresponding to the tentacles.

Most anemones develop as single individuals from the egg, but in other cases they arise from detached fragments of the foot-disc already mentioned. Observation has shown that these detached fragments develop, in the course of fifteen days, into minute anemones with fifteen or sixteen tentacles. One anemone kept in captivity produced in the course of six years no fewer than 276 young ones. Two of them lived for


ACORN BARNACLES


PERIWINKLE


WHELK



LIMPET, UNDER AND UPPER SIDES

five years, producing eggs at the end of ten or twelve months, which hatched a couple of months later.

Passing over for the present a number of parasitic and other worms, we reach the Echinoderma, a name meaning simply "hedgehog skin." Here we have the starfish, the sea-urchin, the brittle-star, and the sea-cucumber, and other more or less well-known forms. In each we find the skin armed either with spicules or plates of lime, with spines or other defences, while in some the internal organs are strengthened by a like formation. Thanks to this peculiarity, we are able to include past members of this group among the most perfect of all our fossils, won from deposits far removed from present-day seas. While there can be no doubt as to all the echinoderms having had a common origin, it is a little difficult to account for the difference in form between the five-rayed and the two-sided. Presumably the two-sided forms, such as the sea-cucumbers, most nearly represent the ancestral stock. From this common origin has risen a vast division of animals—sea-cucumbers, which are the trepangs beloved of Chinese gourmets; sea-gherkins, all manner of sea-urchins, leather urchins, egg-urchins, heart-urchins, lobed-urchins, wheel-urchins, and starfishes many and curious.

Correlated with difference of outline, we have difference, more or less pronounced, in habit. For example, the starfishes have perhaps the strangest of all methods of travelling. Those five seemingly inert arms, wherewith we are all familiar, are the seat of a marvellously modified system of sucker-like discs, which are protruded and withdrawn at will as each grasps or releases some roughness of surface by which the animal is drawn along or held fast in position. These tube-feet are operated by the squeezing of fluid into them, causing them to protrude and grip with a sucker action. Not all these unique processes are employed for locomotion, however, for in some cases they apparently help respiration. This system of fluid-charged canals extends generally throughout the body, and, while most noticeable in the starfish and certain sea-urchins, is present, with various modifications, in all echinoderms.

The processes of reproduction by the echinoderms are very various. In some instances the larvæ, very unlike their parents, arise from fertilised eggs; in others by budding, by fission, by the sundering of parts. A starfish will deliberately divide itself; but if it be torn limb from limb and the fragments cast into the sea, from each limb another starfish will result! The residue of the body will reproduce the lost limbs; from each severed limb will grow a new body. The brittle-star, which is the most disruptive of the whole brigade, and will shatter itself in fragments when an attempt is made to draw it from the sea, is, however, believed not to have this uncanny resemblance to plant life. But the sea-cucumbers voluntarily undergo division for the purpose of multiplying their kind. Often members of the order produce and liberate eggs; but some of the sea-urchins, notably Hemiaster philippi, retain them, until hatched, within a depression, covered by spines, on the under side of the body.

In some of the sea-cucumbers the young are attached to the body of the parent, while in one genus, Psolus ephippifer, the larvæ attain days of discretion while sheltered under the mushroom-like plates of the parent's back. Similar protection is afforded, by a tent-like covering of the disc, by certain starfish. The sea-cucumber, though it lacks the peculiar reproductive methods of the starfish, is quite as comformable in another way—it can cast up its entire digestive system, lie an empty framework for a while, then furbish up an entirely new interior. Starfish work great havoc in oyster-beds. Straddling the shell of the victim, the assailant raises itself upon the tips of its legs or arms, after the fashion of

EDIBLE COCKLES AND SEA-GRASS

STALKED BARNACLE

THE EDIBLE MUSSEL IN SEAWEED

a five-legged stool, and firmly gripping the bivalve, pulls, and continues to pull, until the oyster's power of resistance gives out.

Omitting many examples of shell-life, mainly of technical interest, we come to a series of animals of economic as well as scientific interest. On the one hand we have such animals as the oyster, enclosed in two shells, or valves, and so known as bivalves; on the other we have such molluscs as whelks, in which the shell is in one piece, and therefore termed univalve. Very striking life-stories are here for the reading, such as that of the large swan-mussel of our rivers. The eggs develop within the body of the parent, which they quit as larvæ, covered by a small shell, that is armed at either end by a strong, curved hook. They settle down upon the mud, with long filaments waving in the water above them. A minnow or other small fish approaches, and touches the threads, which, being sticky, adhere to the part touched. The larvæ is whisked away by the fish, which it manages to approach by hauling in the slack, as a sailor would say; then strikes home with one of its hooks, and clings to the flesh of its prisoner. The wound thus caused produces a kind of gall on the flesh of the fish, and within this the further development of the larva takes place. After about three months the larva has assumed the form of a young mussel, and escapes from its living nursery, returning to the mud at the bottom of the water, to grow into an adult and to bring forth its like.

A SHORE-CRAB BURYING ITSELF TO ESCAPE A FOE

The edible mussel, which is an important item of food to our artisan population, is smaller than the mussel previously mentioned, but, like the former, clings an progresses by an extrusible muscular foot and anchors itself by means of a wonderf contrivance known as the byssus. This i a collection of silky fibres spun by th mussel, as fine and remarkable in its wa as the web of the spider or the cocoon c the silkworm. The mussel is no faddis in the matter of habitat; it is as much a home on a mud-flat as on the piles of a pie or the timbers of a hulk. Feeding upo organic deposits i the water which it re ceives, it assimilate poisonous organism from sewage an other sources o pollution, and whe eaten by a huma being causes seriou illness, and eve death.

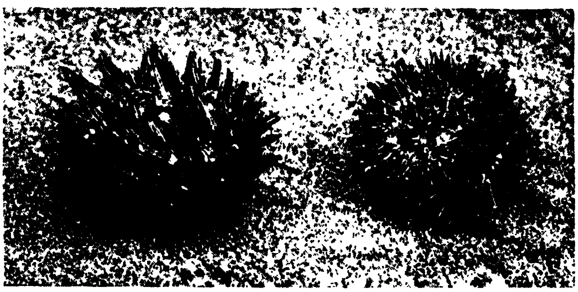
On many account the oysters are th most interesting o the bivalves. The are the only shellfis cultivated by man and, though the cannot compare fo beauty with many o the glorious creation of Nature repre sented in the in comparable gallery o shells at the Natura History Museum still, we have al agreed to place then highest in popula estimation, becaus certain of thei number yield pearls and all of then produce the beauti ful nacre, or mother of-pearl. In th majority of oyster the sexes are united but not in all. Th young are produced from eggs, and thes hatch out into free-swimming larvæ, an lead an active life until the developmen of hard, heavy shell makes natator exercise impossible.

In recent years we have had to rewrit the history of the pearl. It was alway supposed that the intrusion of a grain of sand or other irritating substance between the mantle and the shell caused the

production of nacre to cover the intruder, and so form the pearl. The truth is, however, that nearly every pearl is simply the beautiful tomb of the larva of a loathsome parasite of the fluke or tapeworm kind. pletes its growth, escapes, produces its eggs, and so continues the process of generation. Meanwhile, however, other embryos of the tapeworm have found their way into an oyster which the file-fish

THE HERMIT-CRAB OUTSIDE AND INSIDE ITS WHELK-SHELL HOME

The history of the pearl is really an extraordinary one. It begins with, let us say, a marine tapeworm (a species of Tetrarhyncus), which lives in the intestines of a large Indian ray or of a shark, and its embryos, passing out into the water, enter the shells of the oysters. Those that reach the internal organs of the oyster are in comfortable circumstances, and continue their development until a voracious trigger-fish or file-fish crunches the oyster's shell and swallows flesh, parasite, and all. The



SEA-URCHINS ON THE SEASHORE

misses. Some of these blunder into the space between the sensitive mantle and the shell of the oyster. The latter at once secretes mother-of-pearl similar to that which lines its shell, and the host becomes also a tomb. The longer the oyster lives, the larger the pearl becomes, until, upon a day, the pearl-fisher secures a treasure of price, and the tomb of a parasite is sent to London to take its place in the priceless necklace of a duchess.

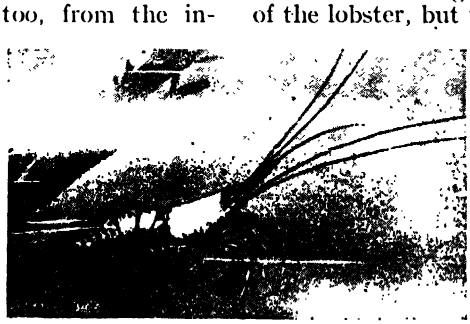
Other notable families of bivalves include the scallops, of which one genus

THE LOBSTER CRAWLING ALONG THE BED OF THE SEA IN SEARCH OF FOOD

file-fish in turn falls a victim to ray or shark, and is swallowed, with the larva of the parasite alive inside it. Within the interior of the new host the parasite com-

(Pecten Jacoboeus) was anciently the badge of pilgrims returning from the Holy Land; the dainty telleus, the exquisite Venus' shells, the mighty clams—some specimens

of which weigh over 500 pounds; the cockles, which by virtue of an amazing power of leaping prove the acrobats of the group; the burrowing and boring gapers, razor-shells, piddocks, and teredos or ship-worms. Leaving detailed account of the land-dwelling gastropods, we note the whelk, with its famous rasping tongue which bores a hole through the shell of the oyster and sucks out the contents; the periwinkles, familiar vegetable feeders living between tide-marks, and notable as possessing, in Littorina rudis, a creature which is carrying on evolution before our eyes by gradually converting the roof of the gill cavity to the purposes of a lung. The limpets, of which there are several forms, are interesting, too, from the inexplicable homing faculty of our common British example, which, descending from its niche in a rock to feed when the tide goes down, returns unerringly when the tide flows back.



THE COMMON PRAWN

A PAIR OF SHRIMPS

The cuttles and their allies have already been dealt with on page 3465, so we must pass to certain sea-dwelling forms of the arthropoda, or jointed-limbed animals. Here we have sea-spiders, king-crabs, which come between the spiders and scorpions and the crustaceans, and two notable extinct orders, the Merostomata and Trilobita. In the crustaceans we find a surprising adaptation to conditions. Invested in a perfect suit of armour, once the adult stage is reached, crab, lobster, and crayfish are periodically faced with a serious problem. Each must have more room to grow than the inelastic shell will allow. The shell cannot expand, so the crustacean crawls out of it. Its flesh becomes flaccid and watery, the limbs are withdrawn, the carapace splits, and, lo, the redoubtable warrior of an hour before is faint and flabby, weak as an egg without a shell. But wounds sustained in the operation soon heal; the dismembered animal grows prodigiously; the skin rapidly hardens into shell once more; and crab or lobster is fit and well for the business of life again.

We have not space to consider in detail the various groups of this interesting order, but the curious parasitic life of the soft-tailed hermit crab; the remarkable habits of the land-crabs, which live two or three miles inland, and, returning to the sea to breed, march in a straight line, climbing every obstacle, from church to haystack; the titanic proportions of a Japanese crab (Machrochira Kœmpferi); the habits of other crabs in the same tribe with the last-named in decorating themselves with sea-weed; and the amazing tree-climbing feats of the cocoanut crab—these are points which must arrest the attention of every student of a subject teeming with interest.

There is nothing new to add to the story of the lobster, but its nearest ally, the cray-fish, though a fresh-water crustacean, might be better known. It lurks beneath stones or under the edges of banks by day, and leaves its retreat only at night, and so remains a stranger to all but the professional fisherman. Our review closes with the shrimps and prawns. The former are by no means restricted to salt water, but it is the marine forms that are edible. In their natural condition they harmonise almost perfectly with their surroundings, but their habit of burrowing in the sand is not unrelated to a fear of fish that swim and see by day. Prawns keep to deeper water, and in Europe are to be found only in the sea, but in tropical rivers prawns occur which match the lobster in size.

Shrimps and prawns equal the crabs, lobsters, and crayfish in one peculiarity—all can at will snap off a limb or so to secure their safety. Perhaps we should not say "at will," for the surrender of parts appears to be a reflex and unconscious act of which the individual knows no more than it knows of the succeeding marvel of Nature in the form of an immediate development of tissue around the sundered part, which prevents bleeding from the wound, and prepares for the replacement of the lost member by a new limb.

THE INMOST SELF OF MAN

The Contradiction, by Human Experience and the Science of the Mind, of a Mechanical Materialism

MAN'S UNIQUE SELF-CONSCIOUSNESS

Our present study of man must conclude with a few chapters which discuss certain obscure but undeniable facts, hitherto ignored by conventional science, but none the less real because the ordinary methods of the laboratory do not happen to be suitable for their observation. But before we attempt to state something of what is known, as distinguished from what men imagine or assume, in this field of "Psychical Research," we shall do well to reassure ourselves as to the scientific character of these studies of the mind, for there was delivered in 1912, from the Presidential Chair of the British Association, a very conspicuous and apparently authoritative statement of the most thoroughgoing and dogmatic materialism we have heard since the Germans of forty years ago told us that the brain secretes thought as the liver secretes bile.

Every statement of any importance that has been made in this section, and will be made in its final chapters, falls to the ground as mere nonsense and superstition if Professor Schäfer's address at Dundee is a true statement of what science now knows of man. Thus, in our last chapter, we tried to summarise the modern study of the Will, and to show that there are certain psychical facts which can only be called the Self, the Character of a man, and the Idea of himself that he entertains—that these are behind the Will, make the Will, direct it, and thus determine the course of our conduct. But all this, which the profound thinkers of many centuries, by their observation of the mind, have taught us, must be dismissed as empty words if we are to accept the materialist view, or the slime-and-water theory of man.

In the address referred to, we have what is, no doubt, as complete and convincing a statement of the materialistic case as can be made. The author is one of the most conspicuous and hard-working physiologists of the day, who made his name in University College, London, whence, in 1899, he was promoted to the Chair of Physiology in the University of Edinburgh. A statement which would be of no importance had it been issued as an atheistic leaflet, without authority of any kind, demands attention when it comes from such a source and is delivered from so high a place; and in dealing with it we shall not feel that we are wasting our time, however familiar to all students may be the answer to the theory of man therein propounded. Here we shall therefore try to compress into reasonable compass this restatement of a materialism which thinkers of today had thought to be forty years out of date.

The nature of Professor Schäfer's views on life is easily defined. "The phenomena of life are investigated, and can only be investigated, by the same methods as all other phenomena of matter, and the general results of such investigations tend to show that living beings are governed by laws identical with those which govern inanimate matter." Here is a bold statement which every psychologist is bound to contradict at once.

The whole conception of the living world, as science and philosophy now frame it, is that it is all one. Nobody asserts this more strenuously than the materialist. His assertions about life must therefore cover the life of man, and we shall see that he is in no doubt, and leaves us in no doubt, on this score. Therefore, when he tells us that the phenomena of life can only be investigated by the same methods as all other phenomena of matter, we reply that the psychological method known as introspection, whereby we observe the working of our own mental processes, is

indispensable in the study of the most characteristic and interesting part of life as it is exhibited in man. And the progress in our knowledge of man, which the past decades have to record, since last materialiism asserted itself so boldly, has been derived from the recognition of the truth that *both* kinds of study are necessary. The psychologists and metaphysicians had too long despised the study which uses the microscope and the test-tube; and the microscopists and chemists had too long been inclined to suppose, as Professor Schäfer still supposes, that they had nothing to learn from the thinkers and the students of their own mental processes. It is the establishment of the new psychology, and of psychological laboratories, used not by mechanics, whose view of life will naturally be mechanical, but by thinkers, that has so greatly advanced our understanding of ourselves, in health and disease, in childhood, youth, and age.

The next statement made is that "all changes in living substance are brought about by ordinary chemical and physical forces." This assertion was promptly contradicted in the "Times" by a famous chemist, Sir William Tilden, who pointed out that in living matter physical and chemical forces behave in a fashion totally unlike what obtains elsewhere.

The Difference Between Using a Force and Being Used by it

But we must distinguish between two statements which are here confused. One is the statement that the laws of physics and chemistry are never contradicted, denied, suspended in the body of any living creature, including man. This is a statement which the physiologist is entitled to make, for its truth has been proved, nor has physiology any greater achievement to its credit. The old view of a "vital force," which was made by living creatures, and supplemented or opposed the forces outside it, has been disproved by science. The forces used by the living creature, including man, are the known physical and chemical forces. He cannot stir a finger without transforming energy, just as a machine does. He requires to be fed with fuel, just as a machine does; and we can show that his body neither destroys nor creates any matter or any energy. This is a tremendous assertion, entirely contradicting the almost universal belief of the past; and so far as all the scientific evidence goes, we must accept it as true, and as therefore valuable. But this, which is proved, is a wholly distinct statement from that which materialism makes—that "all changes in living substance are *brought about* by ordinary chemical and physical forces." The fact which alone has been proved is that, as we said, the forces *used* by the living creature are the known physical and chemical forces, and those alone. The difference between the two statements may be too subtle for some very simple types of mind, but any child can see it. All changes, in an organ of pipes, or in a living organ, such as the brain, involve the action of physical and chemical forces, which the player merely liberates, uses, and directs; but the player remains.

The Radical Difference Between Growth by Aggregation and Growth from Within

Given the simplest form of living creature—though as to its origin we know nothing—we observe that it grows. This fact of growth quite evidently resembles what we observe in the case of crystals suspended in a liquid containing the same substance as the crystals are composed of. The crystals grow, and even multiply. Therefore it was argued in the 'seventies, and has been argued since by those who follow the materialistic teaching of that time, that living things, after all, are no more alive than crystals. Professor Schäfer repeats the argument. But he does not mention the fact, which physiologists themselves have been the first to note, that there is a radical difference between the increase in size of a crystal and the growth of a living creature.

The crystal is formed and grows by the addition of new matter upon its surface, just exactly as a snowball grows, or as a lump of mud grows if more mud is plastered on it. If it pleases a physiologist to call this growth, he must have his way; but other people will prefer to reserve the scientific use of the term for the growth of living things which take their food into the substance of themselves, transform it, and grow from within. The crystal "grows" by "accretion," the living cell grows by "intussusception"—the crystal from without, the living cell from within.

The Complete Difference Between Crystallisation and Vital Growth

To all students of this subject the distinction is familiar, and it goes with the physiological discovery that the oxidation or breathing of protoplasm and the living cell is not upon the surface, but is "intramolecular"; that is to say, the living thing does not breathe and burn at the point of contact with the oxygen, but it absorbs the

oxygen into itself, makes compounds between the oxygen and its own substance, and then performs the act of oxidation when it is required. Hence, the remarkable fact, elsewhere quoted in this work, that a muscle can be caused to contract in an atmosphere of pure nitrogen, and will give off carbonic acid. The muscle has had a store of oxygen combined within its living protoplasm. To these processes of growth and nutrition, as discovered by the physiologists themselves, nothing in the behaviour of crystals or snowballs or mud-pies offers any parallel. It is surprising that this argument should not even have been mentioned in Professor Schäfer's address.

The Empty Arrogance of Materialism in its Entirety

Our concern here, however, is primarily with the life of man; and we must forbear to consider the portions of this address which deal with the earliest forms of living matter, and the now generally accepted view of their evolution by natural processes, and without the interference of a special creative act from outside the universe. We merely note, in passing, how quickly the greatest problems of thought, which have baffled every thinker since thinking began, are solved in modern days. Our long chapters on the origin and development of species, and finally of man, seem so superfluous when a master cuts the knots, as thus: "The establishment of life being once effected, all forms of organisation follow under the inevitable laws of evolution." Here is the empty arrogance of materialism in its entirety. Given a mass of colloidal slime, three parts water, and the cerebrum of Shakespeare and Harvey, the poetry, to say nothing of the physiological science, in which we glory, "follow under the inevitable laws of evolution." So the whole question is begged in a phrase.

A Modern Scientist who Disposes of Modern Science in Half a Dozen Words

It might reasonably have been expected that, when a thoroughgoing materialism made its reappearance in the year 1912, its advocate would deal with the representatives of the opposite school, who are being read and studied and discussed all over the world. The most conspicuous of those representatives is Professor Bergson; and, in our own country, their acknowledged leader, though his name is not so familiar to the newspaper reader as some others, is Dr. McDougall, whose great work on "Mind and Body" has been already referred to, and who is a leader both in physiology and in pure psychology. No mention of these writers is to be found in the address which is under discussion here; its author only says, "At the best, vitalism explains nothing." But, really, can one suppose that it is either science or ordinary sense to deal with so formidable a thinker as Bergson in these half-dozen words, and to pass on, as if the *obiter dictum* of an author who shows no sign of having read Bergson leaves him disposed of?

Too often has this been the method of materialism, and when it only had to deal with, perhaps, some unknown and pious advocate, like the old lady who told Huxley that the fossils were created to try our faith, perhaps there was some excuse; but such a book as "Creative Evolution," which profoundly impressed so eminent a psychologist as Professor James, and has since been the subject of more discussion by thinkers than any other book of the time, requires to be answered.

The slime-and-water theory of life and man requires to make the transition from organisms which consist of only one cell to those which consist of many. The teaching of biology, and of all physiologists, hitherto, including such great writers as Huxley—whose "epi-phenomenon" theory of the mind we have already discussed—is that the bodies of the higher animals and plants are not aggregates, but organisms.

The Principle of Unity in the Measureless Multiplicity of the Body

True, they consist of many cells of many kinds, but these cells are not merely aggregated. They are *organised*, made into organs, which themselves are made into the organism as a whole. Hence, in this billion-fold multiplicity there is a unity—the unity of the organism. In our study of the behaviour of the leucocytes, of the osteoblasts and osteoclasts, which lay down and chisel the bones, and in every page of our physiological and psychological account hitherto, we have tried to show what is the central fact which physiology demonstrates and asserts—namely, the existence of this principle of unity in the measureless multiplicity of the body.

It could be shown that Professor Schäfer himself, in some of his celebrated researches, has notably contributed to our knowledge of the truth that an organism *is* an organism, not an aggregate, because of some inner unity, such as makes the difference between a cathedral, which has the unity of the architect's purpose and design in it, and a heap of building stones. But in this address

we find Professor Schäfer telling us that "our life"—he definitely includes the lives of men as well as of microscopic moulds—"is the aggregate of the lives of many millions of living cells of which the body is composed." Here we have the very principle of an organism explicitly denied. The unity of structure and function, the identity of the individual, are disposed of; and the explanation of, say, a life devoted to some consistent purpose, or of a great organic work of art, is that it was produced by the aggregate lives of a number of microscopic cells—which, however, live and die, and are born, over and over again in the history of the individual.

This denial of the unity of the organism renders unnecessary, for those who make it, any search for the factor or principle by which that unity is achieved. But the rest of us must continue that search. We have already seen the answer of modern thought. It is the new-old answer that the principle of unity is psychical—that something which is not any kind of "chemical and physical forces," and the existence of which materialism now afresh denies. The necessary answer to this denial was splendidly made by Professor Patrick Geddes, one of the greatest biological thinkers of our time.

A Defence of the Psychical Side of Bodily Processes

Professor Geddes said that the chemists and physiologists were very limited in endeavouring to confine the problem of life to their own subjects alone. The President thought that, when he gave a man anæsthetics, he had suppressed his mental life, and that the bodily life could then be studied quite apart, whereas the mental life had only passed from the obvious to the latent phase, just as in sleep, and was still performing one of its greatest functions—namely, that of keeping the whole organism together. The animal had its senses, its feelings, its dim intelligence. Even a plant perceived light. There was psychic life everywhere; and it was time for the physiologist and chemist to admit psychology to the rank of a science, and carry their own studies forward until they could use both the mental and the bodily point of view. They would then see that what they called bodily processes had their psychical side.

Here, in a few words, is the answer to the old question, What organises the organism, keeps it together, and gives it its unity of plan and purpose? The reader who desires to follow this distinguished thinker further would do well to consult the volume on "Organic Evolution" lately contributed by Professors Geddes and Thomson to the "Home University Library," and with that volume should be read, as complementary for the study of man, the volume on "Psychology" by Dr. McDougall. From these authors, who are not echoing the stale and long-discredited materialism of the 'seventies, he will learn how far the modern study of man has brought us out of the muddy waters of those days. And he will learn what comment is to be made by observers, who are thinkers too, upon these words, carefully repeated in Professor Schäfer's address. "Our own life, like that of all the higher animals, is an aggregate life; the life of the whole is the life of the individual cells."

The Temerity of Pronouncements on Such Questions as Immortality

One touch of humour is added when we find the Professor approvingly quoting Shakespeare: "What a piece of work is a man! How noble in reason! How infinite in faculty! In form and moving, how express and admirable! In action, how like an angel! In apprehension, how like a god!"

Only one other sentence need be quoted from this address, for a protest against the misuse of scientific authority which it involves. Discussing the phenomena of death, and their ultimate inevitability, Professor Schäfer concludes against the possibility of the indefinite continuance of life, and says "We can only be immortal through our descendants." To this categorical denial of immortality the only necessary reply is that no man of science worthy of the name, no philosopher, no so-called—falsely so-called—materialist of the past, such as Herbert Spencer, ever ventured to make it, and that, on this subject—which transcends the capacity of Professor Schäfer's methods, defined by himself as suitable only for the "phenomena of matter"—he is and has no authority whatever.

Was the Brain of Early Man as Large as that of Modern Man?

Science is little served, its functions for mankind are little furthered, the day of its general recognition and appreciation, for the life of the individual and the nation, is little hastened, by such words as these. It is necessary to protest that there is something higher than knowledge—the wise call it wisdom, and Socrates defined part of wisdom for all time when he said that it

consists in knowing what we do not know. It is this wisdom in which the general level of science has always been so deficient, though the verdict of each generation upon the last is the same—they thought they knew, and they did not know.

There is some further knowledge, highly relevant to our present inquiry as to the essential nature of man, the publication of which we owe to the Dundee meeting of the British Association, and this is the place for it. In our study of the brain, its history and its relation to the attributes of man, it was at one time satisfactory enough to compare the size of the human cranium with that of the lower animals. Brain and intelligence went together. Then came an apparently disconcerting and unexpected discovery, regarding the form and size of the cranium, and therefore of the brain, in the ancient race of men usually called Neanderthal, after the place where remains of them were first discovered. The brain of "pithecanthropus erectus," the primitive, almost simian man of Java, must have been small enough, but the Neanderthal brain, judging by the cranial capacity, seemed to be quite as large as that of modern man. The statement was therefore made by anthropologists in general, and repeated everywhere, that the capacity of the brain had not increased during all the hundreds of thousands of years since Neanderthal man was the highest form of life upon the earth.

The Want of Evidence as to the "Thinking Matter" of the Early Brain

In a preceding chapter of this section it was pointed out that the evidence in favour of this view must be carefully examined. So entirely contrary is it to the rest of our system of beliefs in this respect, which seems to show clearly a correspondence between brain and mind, and a great ascent of *mind* during past ages, that it behoved us to ask what the anthropologists had really found. We argued, therefore, that on inquiry the evidence was inconclusive. Cranial capacity is not everything. The real question is the quality and quantity of the grey matter of the cerebrum, and in this respect we had no evidence to show that the Neanderthal brain was equal to modern man's.

The anthropologists should have been more careful to remember the evidence of physiology as to the relative importance of the various tissues and parts of the brain. Further evidence has cleared the matter up. Here it was suggested that the convolutions of the Neanderthal brain may have been far simpler than those of our own, and that thus the actual total of grey matter—of "thinking matter," as it may very inaccurately be called—may have been much less, though the sheer size of the brain may have been as large then as now. As to this we cannot yet say definitely, but there has lately been made the very great and valuable find of what could never have been hoped for—a fossil brain from that remote age. It is called, after the place of its discovery, the La Quina brain, and it beautifully illustrates and confirms much of what we believe about the brain as the organ of the mind.

How a Discovered Brain Contradicts the Suggestions of Discovered Skulls

It is a big enough brain, but its size conspicuously and signally fails just where size is most important. The frontal area of the brain is admittedly the latest and highest in its history. We remember how the cerebrum has developed and grown forwards and backwards so as to cover all the older parts of the brain. Above all do we notice this in the case of the foremost part of the frontal area of the brain, and this foremost part has received the special name of the pre-frontal area. It is the most characteristic feature of the modern brain. What of its presence in the Neanderthal brain? The answer, as furnished us by the La Quina fossil, is that the pre-frontal area scarcely existed at all in those days. This "silent area" of the brain, which is the seat of no sensations, which sends impulses to no muscles, but which is rich in association fibres and has connections with every other part of the brain, must be regarded as the characteristic, essential part of the body of modern man.

The Newest Brain the Seat of Man's Intelligence

Many decades ago, that original and audacious student Professor Haeckel, of Jena, who has been through his long and active life so often right and so often wrong, invented a special and convenient name for that portion, or those portions, of the human brain which are peculiar to it, and which do not directly serve the various functions of motion and sensation as those are served by the rest of the brain, and by the whole, or all but the whole, of the brain in the lower animals. He said that, for this seat of the *phren*, or mind (*cf.* "phrenology"), we must have a special name, and he called it, therefore, the phronema. Now, we have already adduced the evidence to

show that no single part of the brain, nor even the brain as apart from the body, is the sole seat of the mind—for " the mind is as deep as the viscera," as we saw. But there is every reason to believe that the specially characteristic parts of the mind of man, the intelligence, and the Ego or Self, must have their seat in just that portion or those connected portions of the brain which Haeckel calls the phronema; and that the pre-frontal area, which we find to be the newest and most characteristic feature of the modern brain, comprises at any rate a very great and essential part of this phronema—the organ of the central part of the mind.

What are the Unique Attributes that Distinguish Man?

If we follow those anthropologists who believe, as most do today, that the brain of the Australian native is the lowest human brain we know, we may also observe that, in respect of this pre-frontal area, the native Australian brain approaches nearest to the La Quina fossil, with its perpetuation for us of the brain of " Neanderthal man."

It is here, then, in the phronema, that we must find the physical instrument of the essential part of man. For the rest, even if we study the sensory areas of the cerebrum, there are correspondences with brains that are less than human. All parts of man's body other than the phronema may be reckoned as either common to man and animals, or, if peculiar to man, as of no importance. It is the phronema that makes man man; it is even, we see, the phronema that makes modern man what he is, as compared with the indisputably human creatures of the Neanderthal race and its predecessors. What attributes, then, of the modern man are we to name as those which are the essential self of each of us, and which, in all probability, have their especial seat in the phronema, and notably in the pre-frontal area of the brain, which we have just found to be the unique and all-important feature of the bodily structure of modern man?

The Self of Man Something Other than an Aggregation of Cell-Lives

The answer to this question is the answer to the ancient question which all ages of the thoughtful have asked—What is Man? Plainly he is not merely the aggregate lives of all the cells that are found to compose his body. The Self of him is something other than a mere aggregate of cell-lives. It is a psychical something, which uses the phronema as its immediate instrument, through which it rules the rest of the brain and the body. Not in the phronema, but beneath it, occur the processes of sensation and response. Not in the phronema, but far beneath it, in the basal ganglia of the brain, occur the essential processes of instinct and emotion, which are not peculiar to man, but are found in animals generally. At every level beneath the phronema we find what is, in reality, no more than machinery for sensation and reply, nothing but sensori-motor mechanisms. These largely proceed without our intervention or intention. They comprise a very great and necessary part of our psychical life—but a part which many of the lower animals have as we have, and which is therefore not specifically human.

But we saw that there is a something called the Will, which shows itself notably by the process of inhibition or control, exercised upon all the reflex, sensori-motor, and instinctive machinery which is so much older than we are, or man is. This fact of will and self-control was discussed in our last chapter. But the reader who recalled the feats of " cerebral localisation," in regard to such matters as speech and vision, might well have asked—Where is the centre for inhibition? In which convolution of the cerebrum do we find the centre for the Will?

The Seat of Self Found in the Centre of Self-Control

Where is the area which decides that we shall not continue that line of thought, but shall take another? Beyond a doubt there are areas of the brain which are concerned in these processes; and the best we can say is that the phronema is their seat.

This is the centre of will, and of self-control. It is the centre of attention, or of what Wundt calls " apperception," the process whereby the whole self is brought to bear upon any subject. *And if the phronema is the centre for self-control, plainly it must be the centre of the self which controls.* Here must be, so far as we can name it, the seat of the human Ego. Now, this view corresponds exactly with a certain fact of the human mind which has elsewhere been briefly referred to—the fact of self-consciousness. This is a term, of the highest value in philosophy and psychology, which has unfortunately come to have a restricted meaning, of little importance, in common speech. But here we shall use it in its proper sense, as meaning the power by which a man is conscious or aware of himself as a person, a personality, who looks outward upon all things.

In the attempt to find some absolute mark of distinction between man and any animal, we have had to reject one obvious characteristic after another as inadequate. Either we find that some animal does possess the characteristic, as well as man, or else we find that the characteristic does not in the least explain why man is man. This alone does, that he is conscious of himself as a self. No animal has intellectual power enough, and it is very likely that even Neanderthal man had not intellectual power enough, to frame this conception of the self, much less to be conscious of it, to form ideals of it, and to act in accordance with them. The human infant, "new to earth and sky . . . hath never thought that this is I," as Tennyson says. Only in the course of time, after long thinking of himself as a person outside him, and saying "Jack wants cake," does the boy learn to say, "I want cake." The idea of the *I*, which is probably the unique mark of modern man, has now been attained, and will not thereafter be lost, excepting only in some forms of insanity.

The Concept of a Self the Distinguishing Characteristic of Man

This psychical being is now absolutely human, "looking before and after," with the unique human power of living the inner life of the self, in any circumstances, of looking to time past and time to come, of figuring the self, and in imagination conducting the self, in any conceivable circumstances. The bonds of time and space are snapped; the creature is made "with such large discourse," to quote Hamlet again, that it can live its essential life of thought, imagination, aspiration, when and where it pleases. We can scarcely doubt that the seat and instrument of this unique psychical attribute of modern man is the phronema, which is the unique part of his body.

The facts beautifully consort with one another. The phronema, we said, must be the seat of self-consciousness, and of the powers of volition and inhibition. The two go together. An animal may have certain kinds of volition and of inhibition, but we do not see in any animal, however intelligent, the *absolute* volition, almost "godlike," which we see in the man who is sovereign of himself and rules his kingdom for an end conceived within himself alone. When we tried to analyse the essential facts of the human will, in its really willed acts, we saw that it depends, above all, upon the very Self, and upon the idea of the self which a man has. But a man cannot have an idea of himself, he cannot have a sentiment of self-respect, which makes his will, unless he is self-conscious. The capacity to conceive of oneself at all, and say "This is I," underlies the possibility of forming any particular idea of the nature of oneself, any particular ideals as to what oneself is to achieve; nor can a man have, and be, influenced by self-respect unless he has the power of forming the concept of a Self to respect.

The Self One with Will, and the Centre of Our Psychical Life

Hence, clearly, we are justified in looking upon the phronema as the seat *both* of the characteristic human power of self-consciousness and of the human will, which we have just proved to depend upon the development of self-consciousness. Here is the very nucleus of the self. It is true that the cells of the body are alive; and on our view of life as psychical in essence, every cell has a psyche, or "soul"—in Haeckel's bold phrase—of its own. We must admit, and have admitted, that the *psyche* or psychical component of the life of every cell must contribute, somehow, to the total psychical life of man; indeed, much of our modern understanding of certain insane states of mind, and exalted states that are not insane, depends upon our appreciation of the part of the mind which is, so to say, derived from the various organs of the body. But while this is true, it is no less true, and is indeed a fact of immediate experience for all of us, that our psychical life has a kind of "core" or "nucleus" or "centre"—of course we can only use physical images to express the non-physical—which we call the Ego or the Self. This is, indeed, one with the sovereign Will, which, when it is in action, we feel to be the very self of ourselves.

The Recent Return of the Soul to Science

This core or centre, this intensely conscious, because self-conscious, nucleus of the personality, is the unique characteristic of the psyche of man, and places him even a world apart from the highest of the higher animals. Its seat, we must believe, is the phronema. The *whole* of the mind must be said to have its seat in the *whole* of the body —no less. But we have here attempted to distinguish from the whole of the mind that part of it which is unique in man, and which is unique in each of us. It is in many ways conditioned and modified by the rest of the mental and bodily characteristics. The emotions and instincts that pass to and fro beneath it have their echoes within itself.

The processes of sensation and association, occurring in the rest of the brain, and depending in large degree upon the natural quality of the cortex in those areas—all these affect the Ego or Self. The phronema, we saw, though in a way apart, aloof, withdrawn, is yet most intimately connected, by "association fibres," with every other part of the brain. The Self is no more divorced from the rest of the psychical life than the phronema is divorced from the rest of the brain and the body. But phronema and Self are nevertheless distinct realities.

In a previous chapter, when studying the senses and the nature of sensation, we came to the conclusion that, after many years of exclusion from scientific thought, *the soul returns*. A something, for which this is the natural word, must be the unifying principle of the body, and the very centre of the mind. It is from this Self, and according to its total character—"born" and "made" that proceeds the will which directs the actions and history of the body so long as the body can be held together.

The Soul the Unique Personal Nucleus of All Our Life

It is not an unchanging thing, in a world of change, this "soul," but a being which, just because it is a "living soul," changes with experience, changes as the result of its own acts, yet "the more it changes, the more it is the same thing." This is the *I* of each of us, the Ego, which is a new thing in the universe, unique and original in every one of us. To it we refer all our judgments; its interests, whether for itself or for others, are our interests; and when we say "What will become of me when I die?" it is of the Soul, the unique personal nucleus of all our psychical life, that we think.

Such conclusions as these naturally lend supreme importance to the scientific study of that portion of the brain which we seem to have proved to be the immediate seat of the Self of each of us. The discovery of the La Quina brain very greatly accentuates our sense of the entire inadequacy of our knowledge of this part of the brain. Not until this demonstration of the essential difference between the modern, fully human —perhaps not fully human !—brain and the Neanderthal brain could we realise how important the study of the pre-frontal area of the brain must be. It has been much neglected by physiologists, for a very evident reason. They study the brain in its relation to the body, and when they find two areas—say, the pre-frontal and the "Rolandic," of which one seems to have nothing to do with the body, and discharges no function of motion or sensation, while the other sets all the voluntary muscles going . physiologists spend their time on the area which gives them results they look for and care about. The areas which they call "silent" interest them no more. Above all, the mechanical physiologist, whose conception of life and of the body is mechanical, cannot be bothered with an area of the brain which discharges no mechanical function that even his delicate methods will discover.

The Great Need for Further Experimental Psychology

Hence the fact is that the part of the brain which alone is distinctively human, and which we have every reason to regard as the immediate physical seat of the soul and instrument of the will, is the part about which we know the least. If our ignorance is to be remedied, we must turn not to the physiological laboratories, where the brains which are experimentally studied are necessarily those of the lower animals—a very obvious reason why the physiologists have neglected the "phronema"—but to those tragic laboratories of experimental psychology, our lunatic asylums. The morbid will teach us much about the normal. If the phronema is the seat of personality, as we cannot doubt, we must avail ourselves of every opportunity of studying it microscopically, in cases where, during life, there have been witnessed such strange phenomena as those of "double," "alternate," or multiple personality, as well as in many others. But to this study of the morbid there must be added a study of the normal, above all in cases where the will and the personality, the distinctive character of the individual, were remarkable in any definite degree or direction.

The Demand for a Scientific Study of the Best Brains

The "higher criticism" of the brain, as we may here call it, has too few opportunities, and will have, until the state of public education and interest in these supremely interesting problems of man are developed enough to afford us those opportunities—provided for by the deceased as a last legacy to his species. Very occasionally, but with perhaps increasing frequency, we read of such bequests; and the development of psychology has now reached the point at which, if further progress is to be attained, we must be able to study the brains of the thinker, the pioneer, the artist, the genius, nay, the hero and the saints who are more human than the common run of men.

THE HEALTH OF THE MIND

The Question of Sex in Relation to the Growth of Well-Balanced Minds in Childhood

COUNTRY OR TOWN LIFE FOR CHILDREN?

FROM the care of the senses, which are the avenues of the soul, we pass to the care of the mind, the *psyche*, the soul, the conscious self, the happiness of which, on some plane or other, alone makes life worth living or bodily health of any importance. Here we shall accept the profoundly true idea that the *psyche* is a living being, that "to live is to change," and therefore that we must begin at the beginning, and care for all the stages of development if we wish for a healthy and happy mind. And then, if we are wise, we shall not relax our care, but shall seek for a normal and healthy passage of the mind from its mature to its post-mature—which need not be its "senile"- state.

The study of mental health must therefore depend upon the laws of mental development, as the study of bodily health must depend on the laws of bodily development. In very large measure we cannot practically distinguish between the two, so closely are mind and body connected. The reader who obeys the laws of bodily health, as science defines them, and as we have tried to lay them before him here, is also obeying the laws of mental health, so far, but there are further laws, which concern the psychical sphere alone; and at a time when morbid, erratic, unstable states of mind are probably commoner than ever in the history of our civilisation, we shall do well to study the laws of mental health as if they mattered supremely, for they do.

We begin with the child, because, though it may never be too late to mend, there will be nothing but mending unless we begin rightly. But no observance of the laws of mental health is going to produce equal results in all of us, any more than similar physical exercises will make us all swim the Channel. We know that there are some hundreds of thousands of persons in the British Isles at the present moment for whom no mode of nurture will ever provide mental health, or even a colourable imitation of it, and of whom the same would be true however admirable the conditions to which they had been subjected from their birth. Beyond these hundreds of thousands there are probably a much larger number for whom the conditions of nurture, bodily and mental, will decide, or have already decided, whether they enjoy mental health, or pass over on to the wrong side of the scale.

But the last inference to be drawn from these propositions is that the laws of mental health may therefore be ignored; and that, in fact, what must be will be for all that we can do to prevent it. On the contrary, while we have asserted that there are many to whom no laws of health will award mental soundness, there are many more whose fate turns upon the observance or non-observance of those laws; and we may add there are still many more whose mental health will probably defy almost any infraction of those laws, or would, at any rate, suffer no lasting damage therefrom. The wise hygienist of the mind will therefore neither promise what he cannot perform for the first class, nor threaten what will not be exacted from the third class; but he will urge with all his powers that we ought to learn and practise the laws of mental health, especially for that very large number of persons who will be happy, healthy, and useful under right conditions, but unhappy, unhealthy, and a burden to others under wrong conditions.

The whole duty of infancy is to sleep and feed. The portions of the brain which correspond to the conscious and self-conscious level of the mind are not yet in being. They have been laid down in general plan, but the essential structures are not yet completely formed. Our duty, in regard

to the future mental health of the child, is almost wholly a physical one. We shall none of us fail to recognise the importance of right food for the nurture and construction of the young brain, but we shall very probably fail to recognise the value of sleep. A child's desire for sleep is not part of its "original sin," but part of the original reason and rightness of its construction. Sleep is the child's time of growth and development. During the day it is stimulated, takes in nourishment, practises for the future in the form of play; asleep, it assimilates into new tissue and structure the nourishment of the day. Few children of any age get enough sleep for the highest and best mental development, nor sleep of the best quality.

The Importance of Children Sleeping Where There is no Noise

The sleep of the infant and of the child must be undisturbed, whether from without or from within. The disturbances from without are too frequent in nearly all working-class homes. The parents may contentedly observe that the child sleeps through the noise, and, since they assume, like everyone else, that sleep can be measured in quantity, but is all of the same quality, they do not realise the importance of letting a sleeping child be exposed to as little noise as possible, even though it is not wakened by the greater volume of noise. The *depth* of the sleep is as important for the right development of the child's mind, and its future health, as is its length. If noises impinge on the ears, or lights on the eyes, the child's sleep will become shallower and less restful, even though it does not wake. There will be dreams, or even nightmares; and this remains true even though, perhaps, the child has no recollection, and therefore no complaint of them, when it wakes. Everything we now know about sleep, and the *many* conditions of the brain which can be included under the single external aspect of sleep, emphasises the importance of the warning here laid down.

The Special Need for Sleep in the Cases of Clever Children

So much for disturbances from without, but disturbances from within are even more important. The brain cannot rest and develop properly if it is constantly receiving messages from the nerve-supply of the abdomen, and especially of the stomach. If really valuable sleep is to be obtained, the child's stomach must be at rest. The child is not one of those animals that normally sleep after a full meal, and can scarcely sleep without one. Its meals should taper off towards the end of the day, so that it may sleep properly. The child is not likely to have its sleep internally disturbed from the heart, or any other source but its stomach. If we attend to its sleep, especially in the two directions here indicated, we are probably doing more for the future health, stability, and happiness of its mind than could be done in any other one way.

If these assertions are true and important for ordinary normal children, far more so are they for all children of nervous type, all who inherit the neurotic tendency, all who are peculiar, irritable, precocious, prematurely specialised, abnormally clever. Whenever and wherever the brain displays a high degree of activity during wakefulness, there it requires all the more care during sleep, and plenty of it. There is reason to think that, in many essentials, individuals of the human species degenerate from childhood to maturity; we seldom fulfil the promise of our youth. If this tendency, which we share with many other living species, is at all controllable, it would probably be hard to find any more hopeful means than giving the young brain plenty of sleep, for the better development, if possible, of its highest parts and functions.

The Need for Keeping the Child Childlike Without Forcing its Mind

Just as the limbs need exercise for their health, so does the mind, and not least the growing mind. Nature knew this before we did, and knows it much better. There is no reason to suppose that we can prescribe for the child's mind better forms of exercise than it tends to prescribe for itself. Apparently we argue that it is a pity and an infirmity for any man, even though he be so highly endowed in maturity as the Apostle Paul, to speak and feel and think as a child, when he is a child, as Paul tells us he did. We err greatly.

It is proper for a child to be childlike, and for a man to be manly—and as childlike in some essentials as he can. It is not proper for us to suppose that the child's mind can suitably be withdrawn from its own tendencies, and have ours prescribed for it instead. We can direct, and protect, and discipline, and help, and point the moral, and explain the difficulty, but the initial *élan* and trend must come from the living mind of the individual child. Especially can we do nothing worse than try to impose upon the child's mind ideas of a formidable kind which were invented by adults, but which are so familiar to us that

"O SLEEP! IT IS A GENTLE THING!"

THE MINISTRY OF SLEEP, MOST NEEDED BY THE TIRED CHILD. BY MR. HUGH CAMERON

they affect us little, especially since we are less sensitive than children. This applies, above all, to the teaching of religious ideas to children. Not only noises and lights may spoil a child's sleep. Ideas have their potency, too, and phrases like the "unpardonable sin," the "worm that dieth not," and many more. It is a crime to frighten a child; and whatever the aim or the agency may be, the act is criminal none the less.

The Cruelty of Playing on the Child's Susceptibility with Religious Terrors

The force of ideas is tremendous in childhood. Because the child is not interested in the particular ideas which affect us, we suppose that it takes little stock in ideas at all, but that is not so. A child is as "suggestible" as an adult, and more so. It has but a scant supply of organised knowledge of its own, and the superior size, strength, knowledge, experience of its elders make it highly receptive of such of their ideas as it can understand. This suggestibility is very desirable, no doubt, and plays a large part in the history of the generations of men and their doings, but it involves serious risk if the child is not properly protected. All nurses, domestic servants, and so forth, who are found frightening children with stories of hell, or of bogies, or of anything else, real or unreal, for good purposes or bad, should thereupon be deprived of the opportunities they so abominably abuse. Many children are thus frightened, and receive no permanent hurt, but many others, of different mental constitution, and including among them not a fine and precious quality, may be injuriously and even permanently. The *modus operandi* of such injury is to interfere with the quality or the quantity of the child's sleep, or with both.

The Fallaciousness of Regarding the Child as a "Little Man"

So long as utterly false notions of Nature and education prevail, present and future mental health of children will continue to be injured by the parental idea that no time must be lost in turning the mind of the "little man" into a man's mind. Hence the forcing system in education. But the child is a *child*, and not a "little man." No one could endure children, or would continue to produce them, if they were little men and women, instead of being a separate race—a prophetic race, indeed—with qualities of their own. They will turn into men and women soon enough; and if these men and women are to have healthy, stable, and happy minds, the natural sequences in the history of children's minds must be recognised and respected. No good purpose can be served by hastening them.

Parents and teachers sometimes talk as if they really supposed that only by their assiduous efforts can a child be made to grow up at all. In many respects we are, in fact, called upon to do far less, as well as far other, than we suppose. Our concern should be far more with *physical* necessities, and far less with supposed *psychical* necessities, in early life, than we used to imagine. Our delusions in this respect have been long in dying. In 1871, at the dawn of national education, John Ruskin observed and condemned them. He saw that we were going to begin not at the beginning, which is physical, but at a point and in a way where no beginning could ever be justified at all. Here is his observation on the subject. "Every man as good as his neighbour! You extremely sagacious English persons; and forthwith you establish competitive examination, which drives your boys into idiocy, before you will give them a bit of bread to make their young muscles of!"

Our Assiduous Work in the Direction of Over-Pressure

For four decades since, as today, we have been largely engaged in educating our children "into idiocy," or something like it, principally because we have no idea of the real nature of the educative process, not having begun with scientific ideas of the nature and natural destiny of the young human being. It would never occur to us that any special process of education was required in order to turn a caterpillar into a butterfly, because we know that that is the normal course of the life of a caterpillar, but we cannot apply the same simple conception to the case of the young of our own species. If we could, we should see that our functions are much more moderate in character than we supposed.

While we assiduously work upon the child, for the sake of its mind, in the direction of educational over-pressure and "competitive examination," we tend at the present day to sin by omission almost as grievously as by that kind of commission. The supervision of the reading of children, which was almost universally practised in times not remote, has largely disappeared, though the need for it is more urgent than ever. Reading is, above all, the nourishment of the child's mind. The art of reading, as a popular and general art, is now so familiar to us that we forget how recent it is.

When first it became the rule for all properly cared for children to be taught to read, the potency of this new acquirement was well recognised. We have only to go back to the history of printing and of education, the history of newspapers, and of the relations of clericalism to popular education, in order to realise the estimate of the power to read which was framed in old days, when the art was confined to the few. Men knew then that reading meant the entry of ideas which would profoundly modify the behaviour of the reader; they knew that it mattered immensely, therefore, for his "soul's health" and his body's health, what he read. Books which contained what it was thought desirable for men to read were honoured above all things; dangerous, unhealthy books were publicly burnt by the common hangman. It occurred to no one that what one reads does not much matter.

That estimate of the written or printed word was not exaggerated, but just. It is we, to whom print is familiar, that fail to realise its immense psychological importance. Human nature has not changed at all since reading and printing were invented.

Changing Ideas Respecting the Choice of Books for Children

The case is only more urgent and important now than then. Ever since it became customary for young people to be taught to read, until recent times, responsible people have taken as much care with their reading as with their food. The idea that a book could contain moral poison was not questioned. It was, perhaps, less clearly realised that ideas not in themselves poisonous might be very injurious to the mental life of a child simply because a child is a child and not an adult. The receptivity of ideas that characterises the child's mind is too often forgotten. Few of us have studied the late Professor James's observations on "ideo-motor action," and the fashion in which ideas lead directly, and often quite irrationally, to conduct. Today the mass of printed matter is so great, it rushes in upon us from so many sides, and the school has so largely taken over the responsibility of the home, that the reading of the young is left to their own choice.

But it needs little reading of biography, little psychological insight, or personal experience of young people, to know that what they read on their own account is what really matters for them. Our forefathers were not too well provided for in this respect. The professed writers for the young had little enough youth left in themselves, and the theory of reading for the young was that it should be "improving," "moral" in a sense in which life is not moral, and deficient in just those directions which youth finds most interesting. Today we have no excuse at all for neglecting to put in our children's way the kind of poetry that Stevenson wrote for them, and the kind of prose that has come from Mr. Kipling in his past hours of genius. In quantity, trash will always be more abundant than treasure, and so, while we have more treasure, we have immeasurably more trash, and worse. It follows, by the ordinary laws of chance, that, unless we interfere, our children are almost certain to encounter trash, or worse, instead of treasure.

Children's Reading Only Effective when it Corresponds to Their Nature

Let us observe that the trash, *and* the treasure which children will read, agree in the essential that they both appeal to the natural interests of the child. Our ancestors made the "little man" mistake, as we may conveniently call it, and assumed that the child would or should be interested in the kinds of question, the kinds of doing, that interested them. In any case, child-nature will be what it is, and the child will only read, in any effective way, what corresponds to its nature. The few great writers for children—and to write as children should be written for is to be a great writer—have succeeded because they began by instinctively rejecting the "little man" theory. They know what a child is, and therefore what a child wants. So do the successful writers of trash. Thus everything which children will read is of one kind; and the only question is whether we shall put in their way the few good specimens of that kind, or let them take their chance with the innumerable host of the bad.

The Absorbing of Bad Influences by Children from Their Reading

A boy, because he is a boy, wants to read about adventures. If boys, and men after them, did not like adventures, mankind would never have reached these remote and northerly islands, but would be gibbering in Asian tree-tops still, for fear of the dangers of the ground. The average, normal boy ought to want to read about adventures, and ought to have adventures to read about. The question is whether he shall have "Treasure Island," or whether he shall read any of the host

of adventure tales, detective tales, and the rest, which are constantly illustrating "ideo-motor action" by leading boys to steal and forge and run away from home and so forth, who would never have given any trouble without the influence of such tales upon them. This kind of thing is constantly happening, and we see occasional references to it in the papers, where a boy has told a magistrate what "put him up" to his escapade; but we forget all about it the next moment. And, as if reading of this kind were not bad enough, we have the kinematograph theatre to run alongside of it in visual terms.

The Question of Sex as it Affects Children

We need not multiply instances of this too familiar kind. But reference must specially be made to a realm of inquiry which has only newly been opened, especially by such profound Continental students as Professor Freud, of Vienna. Hitherto we have all been content to suppose that questions of sex do not exist for children, and that, until the age of puberty, they are sexless. It is now known that this is not true, and least of all is it true of nervous, excitable, precocious children—those who persistently bite their nails and have other bad habits. Such celebrated instances as those of Byron and Heine show that children, especially those of exceptional and partly morbid type, may fall passionately in love before they reach their teens. These cases are very rare, but we are learning that the abnormal, tiresome, and distressing phenomena displayed by many young children really have their origin, as a rule, in the sphere of sex. Precocity in children is particularly to be studied and cared for. We are not to be unduly alarmed at it, but most certainly we should not congratulate ourselves upon it, nor attempt to encourage it. Very often it is associated with a premature and abnormal development of the part of the child's nature concerned with sex.

The Disadvantage of Stimulating Puberty and Adolescence

But there is nothing that we should desire less than this. Puberty will come soon enough, with its dangers and complications. We do direct injury to any child, boy or girl, when we thrust it into the atmosphere, or give it, or permit it to read, the books which stimulate the development of its sex. It is in the lower types of mankind, or in individuals whose lives are destined to end prematurely, that puberty appears earliest; and the years of adolescence that follow should be long, and the development which takes place during their course should be proportionately gradual and steady, and farthest-reaching in the long run. There is much evidence to show, though we admit the question to be still controversial, that the careful practice of co-education, imitating the co-education of brothers and sisters in the normal family, is beneficial in its influence upon the psychical development of children, not least in the sphere of sex.

For observe that we can err in two opposite directions. We can carelessly permit puberty and adolescence to be unduly and viciously hastened and stimulated in the directions of overt sex by allowing our young people the license, without sufficient occupation, which is miscalled liberty, by letting them read undesirable books, and go to see the "musical comedies" by which, if any memory of them remains, posterity will measure the pretensions of our age. The evils of this course are unmistakable; every physician who specially studies the brain and the mind is familiar with them. Innumerable cases of hysteria, neurasthenia, melancholia, insomnia, neuralgia, depression, suicide, owe their origin to the premature, hasty, vicious, unregulated development of sex in young people.

The Tendency of Modern Habits and Amusements to Weaken Self-Control

In certain grades of our society at the present time this tendency is steadily increasing. Young boys and girls are kept up late at night; they dine too well, with their seniors, and after the theatre they actually eat a heavy supper, though they have taken no exercise at all since the monstrous dinner of less than four hours before. Their meals are complicated freely with condiments and alcohol. Rooms are hot and enervating, theatres are carefully kept hot also, for the comfort of this class of their clients; the play itself is probably a sexual excitant, the dresses of one sex are little calculated to make easier the problem of self-control in the other; and then we marvel and are distressed when disasters happen. We are even so stupid as only to recognise the chain of causation where the disaster is of the nature of a "scandal," but the insomnia, excitability, depression, which we have mentioned, all usually have the same origin.

Now let us particularly observe that the kind of opposite course to which we feel

inclined, for the mental health of young people, when we contemplate these facts, is *not less disastrous in its own way.* The experiment has been made millions of times; its failure in one generation has often been the cause of a reaction towards the other extreme in the next generation. Both extremes are disastrous. At the present moment the upper grades of society are in a phase of the careless extreme, which argues that "boys will be boys," and therefore we should encourage them to be beasts. This phase is simply one of the customary reactions from the other extreme, which was too sufficiently illustrated in Victorian times.

The Unwise Opposite Extreme of Suppressing Natural Curiosity

Now we allow license to the nature of boys and girls; then its very existence was denied or deplored. The boy and the girl were to be kept in the state of childhood as long as possible. Their natural curiosity, natural activity, natural interest in themselves, and in each other, in life and the world, were to be suppressed as inventions of the devil. None of the things which grown-up people permitted themselves were for them. They must ask no questions and they would be told no lies—to quote as doubly and diabolically degraded a saying as words will frame. Outraged Nature avenged herself, as usual; and if hysteria and the other forms of functional nervous disease show themselves as the consequences of the premature excitement of sex, they are no less likely to appear as the consequences of its attempted suppression.

Here, as elsewhere, the "golden mean" which Aristotle commended is the ideal to follow, and by far the most difficult, as it is the most valuable.

The Need for Recognising that Sex in Young People is Normal

To let young people do just as they feel inclined, so long as they observe external conventions, to argue that they must sow their wild oats, and that this is not a bad doctrine for a girl as well as a boy—that road is easy and broad enough. The other extreme, following the lines of what we have here defined as the *old* asceticism, is quite feasible also, for a time. But what may be called the New Asceticism is difficult.

According to this teaching, the sex that appears in young people is not an evil thing, nor yet a good thing, in itself. It is a form of power, a manifestation of vital energy, and, like all other forms of power or energy, it may be turned to good or to evil consequences. In any case, there it is, and there it will be. It can be controlled, but not by the methods we are inclined to adopt. We have to recognise the sex in young people as normal, and as the most potent source of mental power, or mental failure, and psychical health or psychical disease, in all the world. To decry or defame or deny it is ignorant and vicious, and will be disastrous.

As with other forms of power, of which we desire to make the best use, "Go slow" is a good motto at first. Sitting on the safety-valve is not the method. Power which is being inevitably generated must either be drained away in safe directions, or it will cause an explosion and smash the living machine; it may leave the body untouched, but smash the mind, and shake it so terribly that it will never work smoothly and securely again. Thus we come back to the doctrine of the "transmutation of sex"—the doctrine that we must aim at transmuting the crude energy, generated in the living mind and body from puberty onwards, into the higher and subtler activities which have made civilisation.

The Profound Disharmony Introduced by Sex into Modern Civilisation

The recent work of Professor Freud, still far too little known in this country, is in entire accord with the view here expressed. His studies of the psychical life of children and of adolescents, and his attempt to find a psychical interpretation for many forms of insanity, have led him to just this view of the transcendent importance of sex, crude or transmuted, in the lives of us individual human beings, who, from the biological point of view, as has been shown elsewhere in this work, were unquestionably constructed in order to be parents.

In his presidential address to the Section of Physiology at the Dundee meeting of the British Association, Professor Leonard Hill, dealing with the general question of health and the factors of it, just referred to the difficulty of leading a "normal sexual life" as one of the great obstacles to personal health in our time. That is true enough of bodily health merely, but now that we have passed to consider the health of the mind, in its development and its maturity, it is truer than ever. Professor Hill did not offer, and indeed could not offer, any advice for the solution of this problem. It is, indeed, more than a physiological one; it is psychological and sociological, too. There are some seven million unmarried women in this country; there are considerably more

than a million women, over the age of twenty-one, in excess of men over that age. Here, from one sex alone, are several millions of individuals (the unmarried women under forty-five or so) who cannot lead a " normal sexual life " ; and there are large numbers of married women who are in the same predicament. Hosts of men illustrate the problem in the other sex. It is a problem incidental to civilisation, depending on one of those profound " disharmonies," as Professor Metchnikoff calls them, which will have to be resolved by the travail of the ages, before the body and mind of man can blend harmoniously into the mighty chords of the civilisation that is to be.

Puberty and Adolescence the Period when Parental Health is Established

For us, as we are now, we have to recognise the facts of human nature as we find them, not least those fundamental facts of sex which vibrate, in some of many myriad ways, through all of us, and which underlie and affect our whole psychical life to an extent very seldom realised. We have no solution for the problems of a thousand individual cases ; for many of them there is no real solution, for the demands of civilisation, to say nothing of convention, require that the unfortunate individual must be sacrificed, and that some of the deepest ne[illegible]his or her nature must not be sat[illegible]t such solution as there is lies al[illegible]es of self-control and the " trans[illegible]of sex." If this view be sound, [illegible] that *the foundations of parent[illegible] any generation are to be laid at [illegible]d throughout adolescence.*

The U[illegible]osition of Children Plunged Unp[illegible] the World of Pleasure

Let u[illegible] to first principles, let us assume [illegible]facts of sex are natural, that the[illegible] in our nature and affect the whol[illegible]nd, remembering at what age they [illegible]show themselves unmistakably, [illegible]nsider the case of the elementa[illegible]girl, carefully provided for until she is fourteen—the very temperature of the schoolroom regulated to a nicety in accordance with official requirements—and then allowed to do and feel and experience what she will, having been prepared neither by a foreknowledge of her own nature, reverently and honestly taught her, nor by such education as will provide her with interests, occupations, ambitions, towards which she can safely direct the new powers of life that now begin to develop within her.

Or let us take the case of the more " fortunate " sister of this schoolgirl, having her first London season, or of this girl's equally fortunate brother, passing years of his adolescence in the monastic institutions called public schools, with periods of urban dissipation and spasmodic self-discovery during the holidays. None of this is right, because none of it is based upon knowledge of the elementary facts of human nature; and the sign and the consequence of it are to be found in half the hysteria, the instability, the nervous and mental disease, the infirmity of purpose, the misguided enthusiasms, the social dementia, and political delirium of our time.

One other large question must be considered in relation to the mental health of childhood and adolescence. A long-standing tradition favours the country as against the city for the upbringing of children. Against this view modern study of the atmosphere, and of the conditions of sanitation, may urge that children can do just as well in town.

Some Supposed Advantages of Town Life for Children

For one thing, the primary sanitation of our modern cities is now very good, and far superior to what obtains in most rural districts. Town is surely better than country, if town means healthy drinking water and country means typhoid. Then, again, we have much modified our views regarding air. The constitution of the atmosphere does not vary so much in different places as our fathers used to suppose.

Town air need not be at all a bad air. The children may be well housed, with airy nurseries, schoolrooms, and bedrooms, well ventilated and exposed to the sun. In such cases, probably, bacteriological examination of the air in their apartments would prove as favourable as if they were in the country. If the house is properly looked after, there will be fewer insects, flies and others, in the children's house in town than may very possibly be the case in the country. Further, doctoring and dentistry are more quickly and easily accessible in town, and, as a rule, are more satisfactory. Schooling, also, may offer serious practical difficulties in the country, while the town offers great variety and facility in this respect also. It may not be easy or possible to have private tuition in the country, besides which, private tuition lacks some useful qualities of " going to school." As for the village school, with the " rough children," most of us are far too thorough-going snobs to let our children go there. Lastly, as the children grow older, their own

inclinations seem to lead them towards the town; and, what with one thing and another, we decide that things are different from what they used to be in this respect, and that our children will do very well to be town-bred.

Nevertheless, in the judgment of many students of this subject, the proper place for childhood is the country, not just on holidays, but as a home all the year round.

The foregoing arguments, which we have tried to state fairly, are valid as far as they go, but they do not go far enough. They deal with the child's body, but they stop short at its mind. The country life may be made physically as safe for the child as the town life, and safer; but as regards the psychical aspects of healthy development, the town cannot be named for a moment. The last words of wisdom were written on this subject long ago, by William Wordsworth, in a poem, "Three years she grew in sun and shower," which cannot too often be referred to or quoted. That was long before the days of child-study, long before Stanley Hall investigated adolescence, or Freud and his school the "sexual life of children." But the poet's insight, as in many another case, here anticipated the verdict of science. It was one of Wordsworth's finest statements in prose that poetry is the finer breath of knowledge, the "impassioned expression upon the countenance of science."

The Country the Natural Biological Environment for the Young of Man

The poem we have referred to is simply the finer breath, the impassioned expression, of our modern study of mental hygiene.

It may be laid down as absolute that no child, whatever its future psychical history, can ever be quite so happy, quite so healthy, quite so capable of mental enrichment, whether from Nature or Man or books, if its childhood be passed in a town, as if it had been passed in the country. The "country" is simply the natural biological environment for the young of man; the town is an artificial structure, created for and by the adult life of the spe ies. That artificial structure may be made sanitary and safe for the physical life of children. In no case can it supply those stimuli for the senses and the budding soul in which the country is eternally rich, and which Wordsworth describes in words so lovely that the pedestrian man of science will not here attempt to describe them at all. Thus the town must always lack precious things which the country provides for the psychical health of the child.

Further, the town provides what the country is fortunately without. The town was made by and for adults. Its stimuli, its interests, its amusements, are characteristic of itself and of its makers, adult men, and, to some extent, adult women. These it has to offer the psychical being of the child, instead of what the country has to offer. The stimuli and interests of the town are made for jaded palates, for tired faculties of wonder, and for persons in whom sex is adult. They are offered to the child, with its fresh and delicate palate, its keen suggestibility, its astonishing memory for what it can grasp, and much which it cannot grasp until later, and its young, scarcely yet budding, sex.

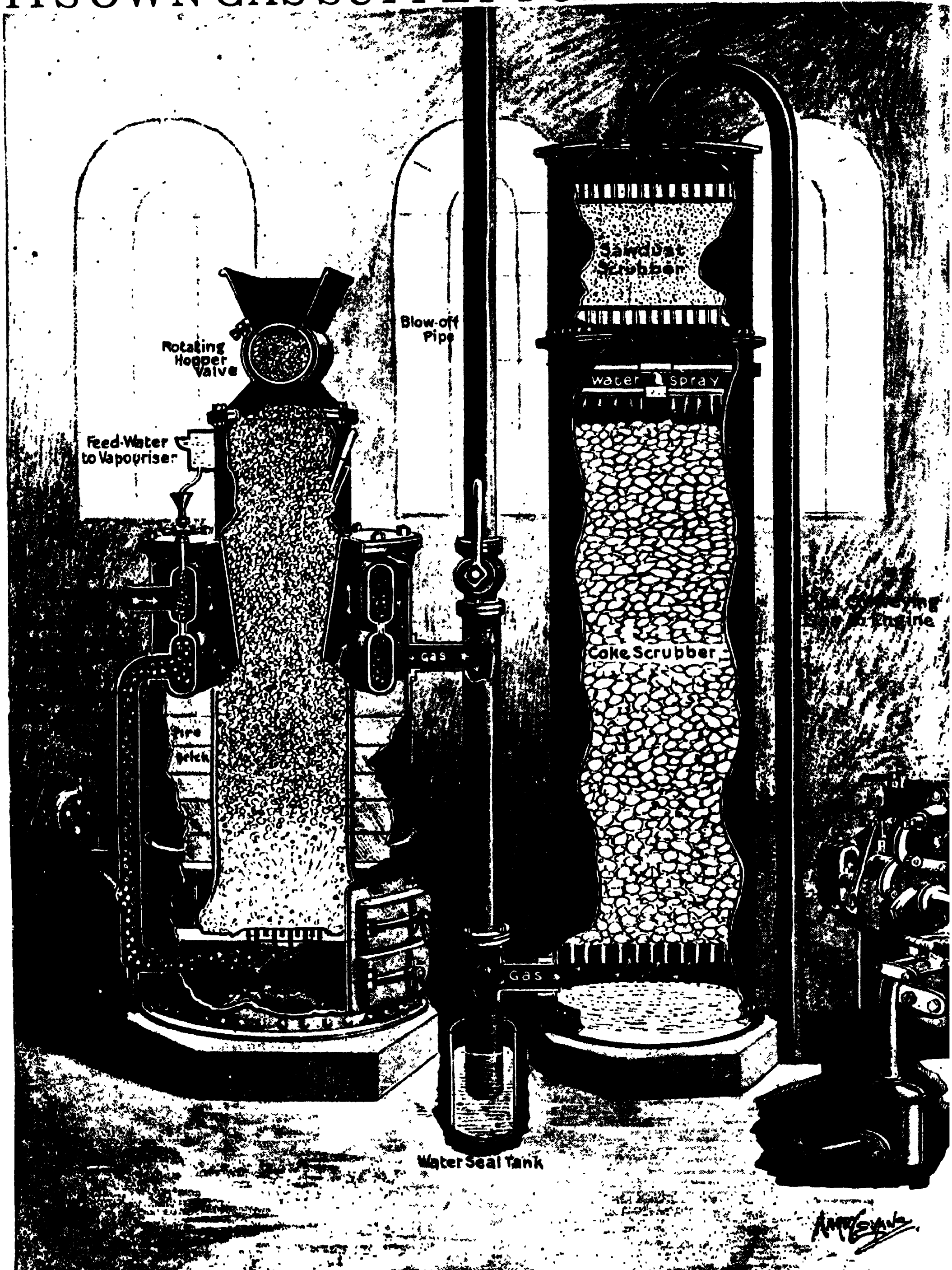
The Prematurely Civilised Child that Never Becomes Highly or Truly Civilised

The town develops the sex and the sex-consequences of the child too hastily. Prematurely civilised, the child never becomes as highly and truly civilised as it might otherwise have become. It must be interested in something, because it is alive, and has life's eternal *élan* within it. But we have withdrawn from it the interests which are fit for its young mind, stars, brooks, rivers, sea, calves, violets, hedgerows, larks, and wheat—those interests through and beyond which at last, and including and sanctifying them all, the child may attain to the full function of the sexual life in the personal love of man and woman; and we have substituted the kind of thing which every reader of these pages knows only too well. The child learns evil things early, necessary things too soon, the best things never. There has been far too much talk, by advocates of eugenics and prophets of evil generally, about national degeneration as an inevitable end, rapidly approached by a senile race. No scientific evidence is adduced for these assertions, and none exists.

The Dependence of Mental Health on the Health-Giving Agents of Nature

The main and essential truth of this matter is that we are trying to do impossible things, to produce health of mind and body without the health-giving agents of Nature, and with the health-imperilling agencies of our own invention. The results are poor as regards ourselves, only too often; they are lamentable beyond measure in the case of our children. But fortunately, in this regard, and in the second decade of our century, the day-spring from on high is beginning to visit us. We are coming to our senses, and beginning to see that, whether or not towns are wisely made for men and women, the country was made for children.

ITS OWN GAS SUPPLY FOR A GAS-ENGINE



This picture-diagram of a suction gas-producer plant shows the method by which a cheap gas for driving an engine is made in an u-rig iron cylinder, and, after passing through a scrubber containing coke and sawdust, which cool and clean it, feeds the cylinder of the engi by way of a small reservoir, which regulates the supply.

The pictures illustrating these pages are by courtesy of Messrs. Crossley Bros., Mather & Platt, the Power-Gas Corporation, John Thornycroft & C Richardsons, Westgarth & Co Mr. Churchill-Shann, and the Pump and Power Co.

THE POWER OF GAS

How the Suction Gas-Plant is Revolutionising Power Production

THE PROPELLING OF SHIPS BY A GAS-PUMP

At the present time our country is considerably behind the Continent, and especially behind Germany, in the use of the gas-engine. Yet when built in large sizes this is the most economical of prime movers; and, particularly in iron, steel, and coal industries, it enables the cost of production to be reduced. The steam-turbine of the mixed pressure type is its most formidable competitor; but the gas-motor is now being so greatly improved that it is most likely that gas-power will eventually form the principal source of industrial energy in all lands possessing large, cheap coal supplies. Both the Diesel engine and the new Bonecourt engine will, no doubt, hold their own in special circumstances. For the most efficient form of gas-engine is exceptionally great in size in proportion to the amount of work it does. It occupies a vast amount of floor space, on which rent has to be paid. And often a gas-generator has to be attached to it for converting the solid fuel into gas and purifying it. In some cases, an abundant supply of water is needed to run the plant and to cool the engine. For these and other reasons there will probably always be room for compact and highly efficient prime movers in which crude oil or tar or gas-raised steam is employed.

On the other hand, some new types of gas-motors are so marvellously economical that it is almost certain they will come into general use where power is required in great and regular quantities. In our country the gas-engine is still suffering from two things—from the fact that it was primarily of foreign invention and out of the main line of the engineering activities of our race, and from the fact that it was formerly notorious for its unreliability. Steam was the national source of power, and most of the existing steam-plants could easily be adapted to new machinery for making use of steam. Again, the early gas-engines were frequently liable to damage through the extraordinary heat generated by the explosion; the cylinders and other important working parts cracked and broke, with a disconcerting frequency.

So we were inclined to leave the gas-engine to the Germans and Frenchmen who had collaborated in its invention. They put up with its inconveniences for the sake of its growing economy in the production of power; they held the master patents, and, by going deeply into the scientific theory of the new motor, they worked out many of the principal improvements in it. In the seventeenth century, according to Milton's friend Andrew Marvell, our race was backward in original invention, but remarkable for bettering the ideas of other nations, and so winning out ahead in the long run. This aspect of our national genius was obscured in the magnificently creative period during which we produced the steam-engine, the steamship, the locomotive, and all the mechanical instruments of the industrial revolution. But it is possible that the characteristic observed by Marvell is a permanent trait of our race. Our own great men often block our way. Our minds are darkened by the shadow of their achievements; the illumination of new paths of progress comes from the foreigner. After Newton, we had to wait for Laplace; after Darwin, we had to attend the resurrection of Mendel; after Faraday and Clerk-Maxwell, we had to wait for Hertz and Lorentz. And after James Watt we had to wait for Beau de Rochas for the idea of the modern gas-engine, and for Nicholas Otto for its practical realisation in 1870, while to the famous French man of science, Carnot, we owed the scientific theory of the perfect heat-engine on which foreign inventors largely worked.

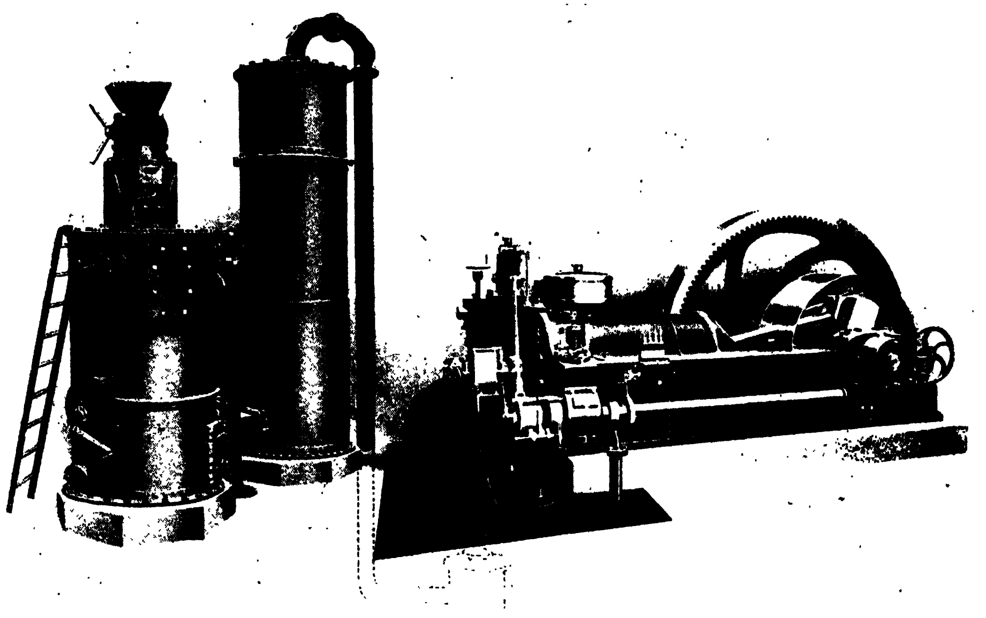
As is well known, the gas-engine was made in a defective form by Robert Street in 1794, when Watt was engaged in developing his steam-engine. But the mechanical details of Street's apparatus were crude. More than three-quarters of a century passed before the gas-motor was elaborated into an efficient source of power by Nicholas Otto, of Deutz, near Cologne. His first engine of the modern type was made about 1876, and exhibited two years afterwards at the Paris Exhibition. From it there have been developed the various forms of internal-combustion engines which have made possible the motor-car, the airship, the flying machine, and the motor-ship. For an oil or petrol motor of the ordinary type is merely a gas-engine, to which is added a device for changing the oil into a vapour. There is no need now to enlarge upon the loss of opportunities for important inventions, which we incurred through our neglect of the first troublesome and unreliable gas-engines. It will be more to the point to trace the steps by which we recovered much of the ground lost. For in many respects we have now bettered the original ideas of the foreign engineers, and some of our firms make gas-engines for Continental use.

After all, it is to Mr. J. E. Dowson that the merit belongs of having really inaugurated the new gas-power era. The gas-engine itself could not have come into general use, and competed widely with the steam-engine, for the town gas employed to run it was expensive. Even with its present economy in the production of work, a large gas-engine running on gas at 2s. a 1000 cubic feet, has a fuel bill equal to that of coal at £1 a ton. And this is in favourable circumstances. The steam-engine would have little to fear from a motor that gave this result. But here is where Mr. Dowson intervened. He set out to obtain a very cheap gas, different from that employed for lighting purposes, but serving admirably as a source of power. In illuminating gas, the coal is merely heated and the product distilled. In Dowson gas, the fuel is actually burnt, but in a peculiar way. Some time before the invention of a practical gas-engine, Sir William Siemens had used a special cheap gas, instead of coal, for firing furnaces in steel and glass making. It is now commonly called Siemens gas. It is produced by burning anthracite or coke in a sort of blast-furnace. This is a tall upright iron cylinder with a firebrick lining. It is stacked with a deep layer of fuel that almost fills it, and more coke or coal is fed in as required from an airtight hopper at the top. Connected with the grate at the bottom is a pipe through which a measured quantity of air is forced into the furnace. This air is only sufficient to burn the fuel just above the grate. The rest of the coal above grows very hot, by reason of the fire beneath it, but does not burn.

THE APPARATUS THAT COLLECTS TAR AT THE BASE OF A PRODUCER-GAS SCRUBBER

This point is very important. An immense number of great industries are now based upon it and it constitutes the fundamental fact of the new era of gas-power. So let us go a little into the science of the matter. The burning or combustion of fuel, the explosion of dynamite, the rusting of iron, are practically one and the same chemical process. It is oxidisation, produced by atoms of oxygen entering into a new combination with the atoms of the burning, exploding, or rusting substance. Coal and coke are impure forms of carbon. When they are burning in an ordinary hearth, the carbon unites with the oxygen of the atmosphere, and make carbonic acid gas. This is known to chemists as CO_2, which means that one atom of carbon (C) and two atoms of oxygen (O_2) are combined in every particle of the gas. This gas is the product of combustion, and will not burn. For as each single atom of carbon has already two atoms of oxygen attached to it, it will not admit any more oxygen into the arrangement.

This is what happens in the fire at the ottom of a Siemens gas-generator. It is st an ordinary coal or coke fire giving off arbonic acid gas. It uses up completely all he oxygen in the carefully measured air-last. Thus there is no oxygen to combine ith the carbon atoms of the upper deep yer of fuel. So this layer of fuel cannot urn, though it grows tremendously hot. t forms an incandescent mass of carbon bove the fire on the grate. But then a urious thing happens. The carbonic acid as from the fire on the grate passes upward hrough the incandescent mass of carbon. t is at once transformed into another sub-tance. For each of its particles attracts an atom of the glowing carbon, and enters into a new combination with it. As chemists might say, CO_2 is changed into C_2O_2, or $2CO$. It is no longer carbonic acid gas, but something called carbon monoxide. Now, carbon monoxide possesses one carbon atom to spare, and this carbon atom is ready to combine with two more atoms of oxygen. In plain English, it is ready to burn. So it is conveyed through a pipe near the top of the generator, and mixed with air and fired, and made to heat various kinds of furnaces. The beautiful pale blue flames which can be seen playing over a deep open coke fire, such as is often made by night-watchmen in an old pail, are carbon monoxide fumes, burning as they come into contact with the oxygen of the atmosphere. But carbon monoxide is not usually rich enough to drive a gas-engine in an economical way. It is chiefly manufactured for heating furnaces, and Siemens gas has been much improved since it was first experimented with.

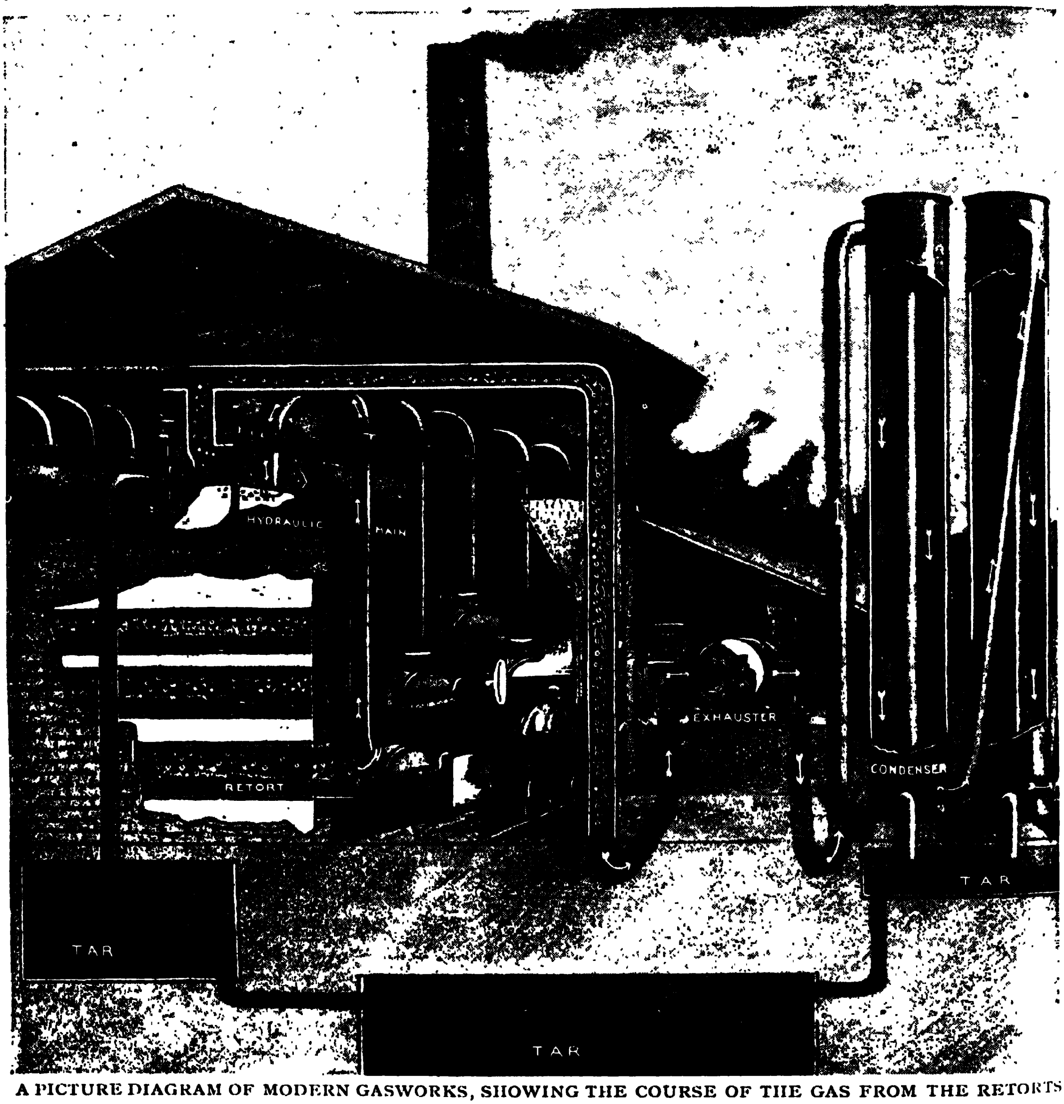


AN ANTHRACITE GAS-PRODUCER AND THE SUCTION GAS-ENGINE THAT IT FEEDS

A far richer gas can be obtained by sending a jet of steam, instead of a blast of air, through a mass of incandescent fuel. The product is known as water-gas. The apparatus devised by the Kirkmans, in 1854, consisted of an upright shaft of brickwork charged with anthracite or coke. A fire was lighted in it, and an air-blast was turned on, until a very high temperature was induced. Then the air was cut off, and a current of steam was injected into the white-hot mass. Steam, as is well known, is formed of oxygen and hydrogen. The oxygen combined with the carbon of the fuel and produced the burnable gas carbon monoxide, and the large quantity of inflammable hydrogen remained and greatly enriched the gas. In fact, the resultant gas was so rich that it could not be used in a gas-engine. Moreover, it was at first very costly to produce. But it can now be made at 3d. a 1000 cubic feet, and, since 1891, it has been used to drive gas-motors.

What Mr. Dowson did in 1878 was to combine the two methods of making

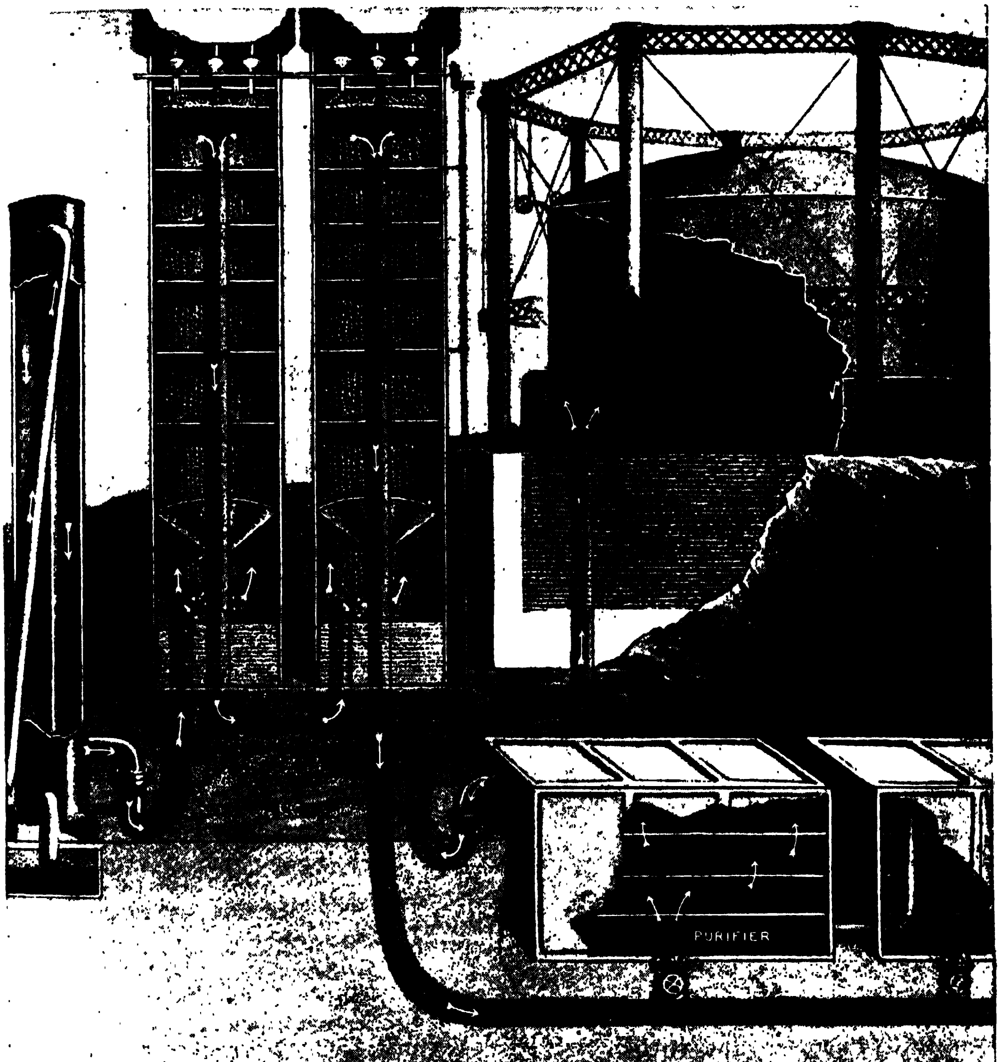
monoxide and water-gas. That is to say, he designed an upright generator with an inlet below the grate, through which both air and steam were admitted at the same time. The current of air was forced in by the velocity of the steam issuing from a boiler adjacent to the generating furnace. The gas obtained was poorer than water-gas, but richer than Siemens gas, and with the proper admixture of air it was perfectly suited for driving gas-engines. It possessed the further advantage of being very much cheaper than lighting-gas. Before the invention of Dowson gas it was considered impossible to work large gas-engines as economically as steam-engines of the same power. With few exceptions, only small motors were made. And, owing to the expense of town gas, it was supposed that large power gas-engines would never compete successfully with the older prime mover. The adoption of Dowson gas first showed it was possible to work a 100-horse-power gas-motor with much greater economy in cost of fuel than a good steam-engine. Indeed, the fact that the larger the power of a gas-engine, the greater the economy of consumption, has now been placed beyond doubt. In large producer plants, gas is now made at a cost of about 2d. a 1000 cubic feet.



A PICTURE DIAGRAM OF MODERN GASWORKS, SHOWING THE COURSE OF THE GAS FROM THE RETORTS

Moreover, there has recently been an extraordinary progress in the constructive

principle and design of the plants. They are divided into two classes—pressure producers and suction producers. Mr. Dowson's first producer was of the pressure type. The generator was completely covered in from the atmosphere, the air was forced in by a powerful steam jet, and the gas was stored in a large gas-holder for use in away with the big gas-holder, and even with the steam-boiler, and make unnecessary the fans and other mechanisms employed in creating the draught. It became possible to use the suction-stroke of the piston in making a slight vacuum throughout the producer, and so suck in the necessary steam and air. But there were some defects



THROUGH CONDENSERS TO THE GASOMETER, AND THE COLLECTION OF THE TAR BY-PRODUCT

the engine. But in 1894, M. Bénier, of Paris, tried to develop the pressure producer into a suction producer. His idea was to leave the generating furnace partly open, and draw the air into the furnace by means of a draught produced by the suction-stroke of the piston of the connected engine. It was a splendid idea. It promised to do in the original design, and the revolutionary suction gas-plant did not become a commercial success until 1903, when Mr. Dowson, among others, effected the necessary improvements. And it was still more recently that another English engineer perfected and enlarged the scope of the new source of industrial power.

And now, after all this explanation, let us glance at a modern suction gas-plant. The fuel enters at the top in a steady stream, controlled by an automatic feed. It fills an upright iron cylinder, at the bottom of which there is a grate on which usually the fire is started. Under the grate is an inlet for the air, and connected with the air-blast is a pipe admitting steam. All the oxygen in the air and steam is used up immediately it enters the generator. The result is that only the layer of fuel at the bottom is able to burn. The fuel above lacks the oxygen necessary to bring about combustion. By reason of the heat beneath it grows very hot, but it cannot burn away. So it forms the heated mass of carbon through which passes the burnt gas from the fire beneath. And this burnt gas, as

THE SMOKY OLD METHOD—A TYPICAL VIEW IN STAFFORDSHIRE, NEAR DUDLEY

we have explained, is changed by the hot carbon from a spent fume of carbonic acid into an inflammable mixture of carbon monoxide and the hydrogen from the steam.

In most gas-producers, the steam necessary to enrich the gas is obtained as a cheap by-product. Between the outer and inner wall of the generating furnace, water is circulated. It prevents much of the waste and inconvenience of radiating heat losses, and, what is of chief importance, it gives off, as it grows hot, the steam required for mixing with the air drawn into the furnace. Carried down by a pipe to the bottom of the producer, it is sucked into the fire and decomposed into oxygen and hydrogen. One of the main differences between a suction producer and the earlier pressure producer is that the latter needs a largish gas-holder. The suction plant, on the other hand, only makes a small quantity of gas at a time in answer to the demand of the engine. For each suction-stroke of the piston is so designed as to draw in to the generator the exact amount of air and steam requisite for the production of the small quantity of gases needed for one working movement of the engine. It is, so to speak, a hand-to-mouth affair, and it has the great advantage of simplifying the plant, and doing away with the big gas-holder. It is for this reason that the suction producer is bound finally to triumph over the more cumbersome and intricate pressure producer.

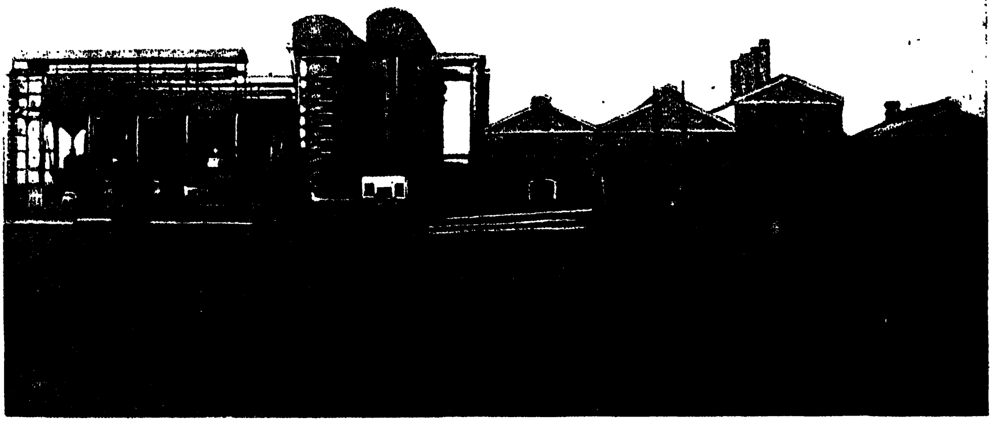
Yet the wonderful suction-plant has some serious troubles of its own. Chief among them is its fastidiousness in the matter of its fuel. It must be fed with anthracite or coke. Ordinary cheap bituminous coal will not do for it. The tarry products would clog the pipes and form soot in the cylinder of the engine. Producer-gas from anthracite or coke is easily and quickly cleaned. It passes from the generator into a vertical iron cylinder filled with coke, on which water is sprayed from the top. The contrivance is termed a "scrubber," and it cools and cleans the gas on its way into the cylinder of the engine. The scrubber, however, cannot remove the tarry products of bituminous coal. So usually some improved form of the older pressure producer has to be used in dealing with this kind of fuel. For when the gas is stored instead of being passed at once into the engine, several devices can be employed

for extracting the tar, just as in gasworks. The most famous of pressure producers for getting power-gas from the cheapest kind of brown coal, or peat or slack, is the Mond gas-plant, already mentioned in POPULAR SCIENCE as a striking example of modern methods of the utilisation of waste. It is stated that, when working with peat, the profit from the sulphate of ammonia recovered from the gas often exceeds 100 per cent. after allowing for the usual working charges. As peat is so plentiful, it is probable that this fuel will be largely used for gas-engines. The only apparent drawbacks to the wide use of the Mond plant are that the gas requires to be made on a large scale, and a plentiful supply of water is necessary. The first producer was started in 1893 at the Brunner & Mond Chemical Works at Winnington, in Cheshire, and another was erected for power purposes at the electric station at Northwich the following year.

Most generators are worked at so high a temperature that the ammonia formed during gasification is destroyed. The essence of the process invented by the late Dr. Ludwig Mond is gasification at a low heat. This is accomplished by introducing into the generator a large quantity of steam, more than double the weight of the fuel. So the fuel is kept at a low and equal temperature; it does not cake, no clinker is formed, and there are very few tarry deposits. At the large plant in use at Messrs. Brunner & Mond's works, each producer burns one ton of slack an hour, and is fed automatically with sufficient for the day. The generator consists of a double iron shell partly lined with firebrick, and erected over a tank of water that keeps it airtight.

As the slack descends it is partly distilled by the hot furnace gases, and the tar is converted into a fixed gas by the heat as it passes downwards. The ashes fall through a circular grate and form a cone extending to the water-tank, and the fresh fuel rests partly upon them. The air and the steam enter at the top between the two walls of the cylinder; they take up the radiating heat of the furnace, and become very hot when they arrive at the bottom of the shell and enter beneath the grate. It is on their contact with the burning fuel that the chemical changes take place. The carbon burns into monoxide and carbonic acid gas, and the heat decomposes most of the steam, liberates a quantity of hydrogen, and also sets oxygen free to combine with the carbon.

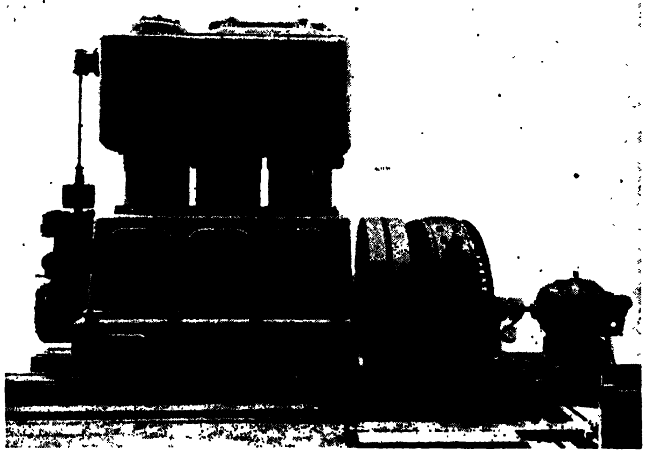
The gas thus obtained is first led off to a set of upright iron tubes, one within the other, which constitutes one of the principal features of the plant. Through the set of outer tubes, the air and steam-blast move on their way to the generator, while the power-gas passes in an opposite direction through the inner tubing. So an exchange of heat takes place; the gas is partly cooled, and the air and steam-blast are warmed before they enter the double wall of the furnace on their way to the grate. From the tubes the power-gas goes into a chamber, where water is kept in violent motion by means of paddle-wheels. The spray removes from the gases the furnace dust and part of the tar and ammonia, and



THE CLEAN NEW METHOD—THE CENTRAL MOND GAS-DISTRIBUTING STATION AT DUDLEY PORT

at the same time much steam is produced. The water is withdrawn at stated periods and the ammonia is extracted from it. In the meantime the gases pass into a tower, where they meet an acid liquid, falling in a multitude of drops into a brick filling. This liquid absorbs nearly all the ammonia in the gases, and it is circulated again and again through the tower, until it becomes a strong solution of sulphate of ammonia.

The power-gas is then conducted into a cooling tower, where it is cleansed from tar and led off into the gas-mains. About one million cubic feet of the gas are used every hour in the works at Northwich. Two and a half tons of steam are required with every ton of fuel, if the ammonia is recovered —where this is not done, one ton is sufficient. In the first case, the yield of ammonia is about seventy-five pounds to a ton of coal slack. By using an excess of steam most of the nitrogen of the fuel is converted into ammonia. The process, as will be seen, is very elaborate, and the plant is expensive, and it would scarcely pay if the market price of ammonia were seriously reduced by the general use of this kind of producer. For this reason it is reckoned by some authorities that Mond gas cannot, except to a limited extent, be expected to supplant other new varieties of motive-power for gas-engines. For if it cheapens its by-product of sulphate of ammonia too much, it may ruin the market for the by-product, which at its present price enables very moist peat to be worked at a profit of over 100 per cent.



THE DUPLEX VERTICAL GAS-ENGINE WITH A DYNAMO

What is generally needed in our country is a suction gas-producer that can burn the cheapest bituminous coal. Compact, easy to work, and wonderfully efficient on the most economical kind of fuel, such an invention would have a wide field of operations, and eventually it would cheapen almost every power-factory product. Naturally many attempts have been made to invent such a plant, but very little success has hitherto been achieved. Recently, however, Mr. G. L. Morton, of Birmingham, after some years of work, has overcome the difficulties in a very simple manner. It is known that the tarry products of bituminous fuel can be decomposed by heating them to a high temperature, and it is by this method that they are got rid of in a Morton generator. Instead of lighting a fire on the grate of the furnace, Mr. Morton almost fills his generator with coke, and starts the coal fire at the top. The coke beneath is blown to a state of incandescence, and the volatile tar passes through this glowing coke and is decomposed into carbon atoms that unite with the spent fumes of carbonic acid gas and combine into the valuable burnable monoxide.

The power-gas escapes through an outlet above the grate, at the bottom of the generator, into a cooler and scrubber of the usual type. No mechanical appliances, such as fans and washers, are required, for all the volatile matters in the fuel are gasified in the generator. Numerous tests made with the plant erected at the Dudbridge Ironworks have given satisfactory results. The average consumption when using Warwickshire nuts was 1 1-10 pounds of coal, giving one-horse power per hour. A very high class steam-engine of the triple-expansion type uses 1¾ pounds of coal at 9s. a ton to produce the same amount of work. Indeed, very few steam-engines attain this efficiency, and from 3 to 4 pounds of coal to every horse-power hour are used in ordinary steam-engines of small size. The plant at the Dudbridge Ironworks supplies a 48-horse-power engine, and good results are obtained from firewood and sawdust as well as from bituminous coal. The efficiency of the suction producer is, in fact, as high as that of the older type of suction-generator that needs the more costly fuel of anthracite or coke. So there is likely to be a considerable demand for it.

Now that the problem of generating power-gas cheaply, automatically, and in a comparatively small space, and feeding it direct into the engine without any big holder and washer, has been practically solved, the attention of many engineers is being concentrated on the gas-engine itself. The modern gas-engine is a very complicated piece of mechanism, in spite of the fact that it does without a boiler, for the producing plant takes up quite as much room as the furnace and boiler of the steam-engine. Even when this space is saved by supplying a multitude of gas-engines with gas from some central plant, distributed by means of mains, the gas-engine is still far from being a perfect prime mover. It is compact and easy to start, but it is terribly spendthrift of its energy. In theory it is much superior to the steam-engine. For the production and utilisation of the heat take place in the cylinder, where a mixture of gases and air is exploded at pressures and temperatures much greater than those developed in the steam-engine.

But in practice much of the tremendous heat of the explosion is not merely wasted, but removed at expense. The temperature is so great that it injures and destroys the working parts, and most of the heat has to be carried off by circulating cooling water in a jacket round the cylinder. In the early double-acting gas-engines, little more than 4 per cent. of the total heat was employed in work. More than half was wasted so that the walls might be kept cool. To this was added the heat escaping from the cylinder in the exhaust gases, with the result that 96 out of every 100 units of energy were dissipated.

This was, of course, disastrous. For it relegated the engine to the museum of useless curiosities. But at the present time the gas-engine of a good type gets more work out of heat than a good steam-engine does. It uses about 35 out of every 100 heat units in its fuel. This is about double the heat efficiency of a good steam engine. This remarkable improvement has been gradually effected by practical engineers working on the lines indicated by the men of science who have taken up the theory of the perfect gas-engine. There has been no large alteration of the main principles of the design, but a numerous variety of small but important devices has been widely worked out to something like practical perfection. Probably the Duplex valveless gas-engine, lately designed by Mr. A. E. L. Chorley, of Manchester, is the best and strongest of the new prime movers.

The next step in the progress of the gas-

GAS-ENGINES USING PRODUCER-GAS IN A POWER-HOUSE AT HONG-KONG

engine will be as revolutionary as the invention of the steam-turbine. As a matter of fact, there are already two fairly well known types of gas-turbines. The first was invented in 1894 by Messrs. Armengaud and Lemale, of Paris. It is now being tried in propelling torpedoes. A mixture of vaporised oil, compressed air, and steam is exploded in a small, pear-shaped chamber. After the explosion, the mixed gases rush through a nozzle, and strike upon the blades of the turbine wheels, which they set moving with great rapidity. The heat is so great that both the combustion chamber and rim, disc, and blades of the turbine-wheel have to be cooled by water circulation. Moreover, some of the chief parts of the engine have to be lined with carborundum or other refractory material to prevent the metal from melting. As yet this gas-turbine has not been developed for industrial use, but a French company is devoting much time and money to the scientific experiments necessary to make it a rival of other types of engines.

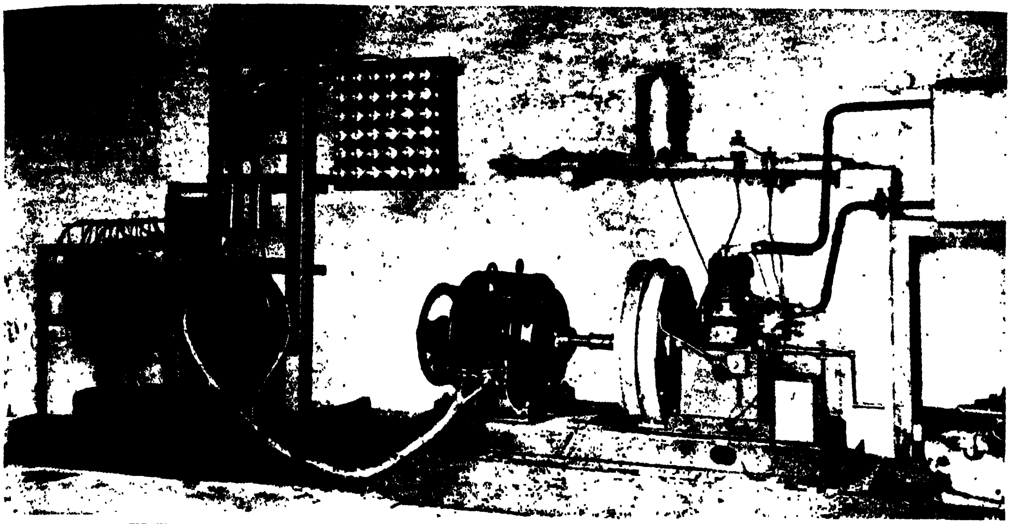
Another kind of gas-turbine—the Holzwarth—is a German invention. In it a mixture of gas and compressed air is exploded successively in a series of pear-shaped vessels arranged in a ring. When combustion is complete, a valve is opened, and the gases enter the wheel. Herr Holzwarth claims that his turbine is remarkably efficient, but his figures have been criticised, and it is quite possible that they require further examination. We think it will be found that the efficiency of a good, practical gas-turbine will be under that of a first-rate gas-engine, but above that of a steam-engine. A few months ago Mr. Montague Churchill-Shann, of Richmond, invented a new kind of gas-turbine that is likely to come largely into use. For it is designed to work with the spent gases expelled from the exhaust-pipe of one or more ordinary gas-engines. It has been long known that the chief loss of heat in an internal-combustion engine occurs at the exhaust. Mr. Churchill-Shann takes this waste product, and sends it through a cast-iron nozzle-ring on to a cast-iron turbine-wheel. An iron wheel-casing, an iron ring of guide blades, and a sheet metal exhaust chamber form the other three main parts of the design.

THE POWER OF GAS—THE SURFACE OF A PARIS BRIDGE WRECKED BY AN EXPLOSION DUE TO A LIGHTED MATCH BEING THROWN DOWN AND MEETING A GAS-ESCAPE

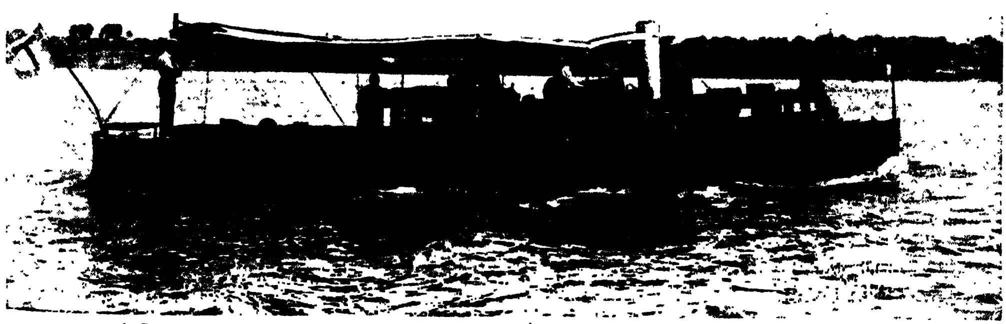
The experimental exhaust gas-turbine was made very small, because it was designed to run with a single-cylinder cycle petrol-motor, the idea being to see if any gain in power was obtained by combining the two small engines. The engine alone produced a mean output of 2·61 kilowatts on 4·17 pints of petrol an hour, when attached to an electric-lighting plant. When the turbine was connected with the exhaust, the mean output was 2·75 kilowatts on 4.07 pints of petrol an hour. The test was thus satisfactory on a small scale. It now remains to be seen if the exhaust gases from a large engine can be made proportionately to increase the amount of work done by the heat generated in the combustion-chamber of the ordinary engine.

Mr. Churchill Shann holds that even his small experimental turbine only needs a different arrangement of the nozzles to develop sixteen times the amount of power from the exhaust of a suitable four-cylinder engine. Certainly if further tests confirm the theory on which he has been working, his exhaust gas-turbine will prove of very great practical value. By helping the gas-engine at its weakest point it will enable much of its wasted working power to be recovered. This turbine was more exhaustively noticed in the "Engineer" of August 23, 1912.

Now we come to the last and by far the most important development of the use of gas-power. Producer gas is now so cheap that the plant has been placed on vessels, and used instead of a steam-engine or oil-engine to drive some tugs on the Rhine. And a small cargo steamer has more recently been fitted with a gas-engine and suction-producer. The great difficulty arises in the matter of speed and reversing. The engine runs at an invariable rate of 500 revolutions per minute, but it cannot be reversed by a movement of a handle, as a reciprocating steam-engine can. The engine would have to be stopped, and the cams altered, in order to reverse the motion,



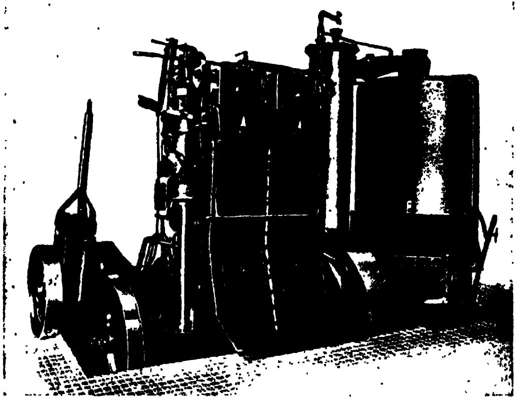
THE EXHAUST GAS-TURBINE AND THE PETROL MOTOR WHICH IT RUNS



A LAUNCH PROPELLED BY A GAS-ENGINE FED BY A SUCTION PRODUCER

and make the ship go backward instead of forward.

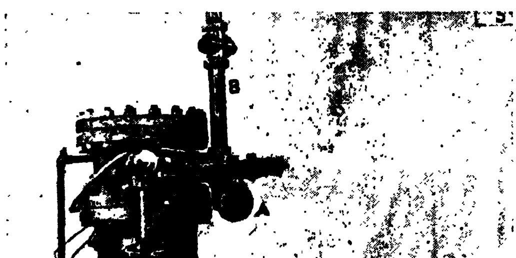
Naturally this would be quite impracticable; all sorts of accidents would occur, especially in crowded harbours, if the steamer could not be sent backwards as easily as she is driven forward. Moreover, the invariable speed of the engine would also be a nuisance, a danger, and a great waste of power. To overcome all these difficulties the engine is connected with a dynamo that supplies current to an electric-motor, and this turns the propeller at a speed of only eighty revolutions a minute. The speed of the propeller can be varied electrically, and it can be reversed by the same means. So full control over the motive power is obtained, and at the same time the speed and direction of the gas-engine remain constant in all circumstances. These are just the conditions under which a gas-engine works best and most economically.



THE MARINE SUCTION GAS-ENGINE

All this is merely by way of introduction. For an extraordinary invention of Mr. H. A. Humphrey, of London, has opened out a field of entirely new ideas in regard to the propulsion of ships. Oars and sails, paddle-wheels and screw-propellers, are but makeshifts. It has long been known that a jet of water issuing from the stern of a ship is much more effective than the best screw-propeller. But a suitable pump has been wanting to form the jets. This is at last available in the internal-combustion pump invented by Mr. Humphrey. It will no doubt take some time to adopt the strange new invention to marine propulsion, but there can be no doubt that it is designed on the right principle. The Humphrey pump is really a gas-engine, in which the piston, connecting-rod, and fly-wheel are all composed of water. There are two tanks, and the water is pumped from the lower tank to the higher. Connecting the two tanks is a pipe containing a column of water. This column of water forms the piston of the pump. Above it in the top of the cylinder, is a combustion-chamber with a cover in which are the valves for admitting the gas and expelling the exhaust fumes. An electric ignition device is fitted in the cover.

To understand the working of this simple but wonderful invention, let us suppose that an explosive mixture of gas and air has been compressed by the water column in the combustion-chamber, and ignited by the sparking-plug in the top cover. The water-valves between the lower tank—called the suction-tank—and the pipe are closed. So, when the explosion forces the water downwards in the cylinder, none of it goes into the suction-tank. The great column of water moves towards the delivery tank. And, owing to the momentum it acquires, it continues to move forward a little, after the force of the explosion has spent itself. So the exhaust gases behind the water have more room in which to expand, and they expand to below atmospheric pressure.



A HUMPHREY PUMP AT WORK

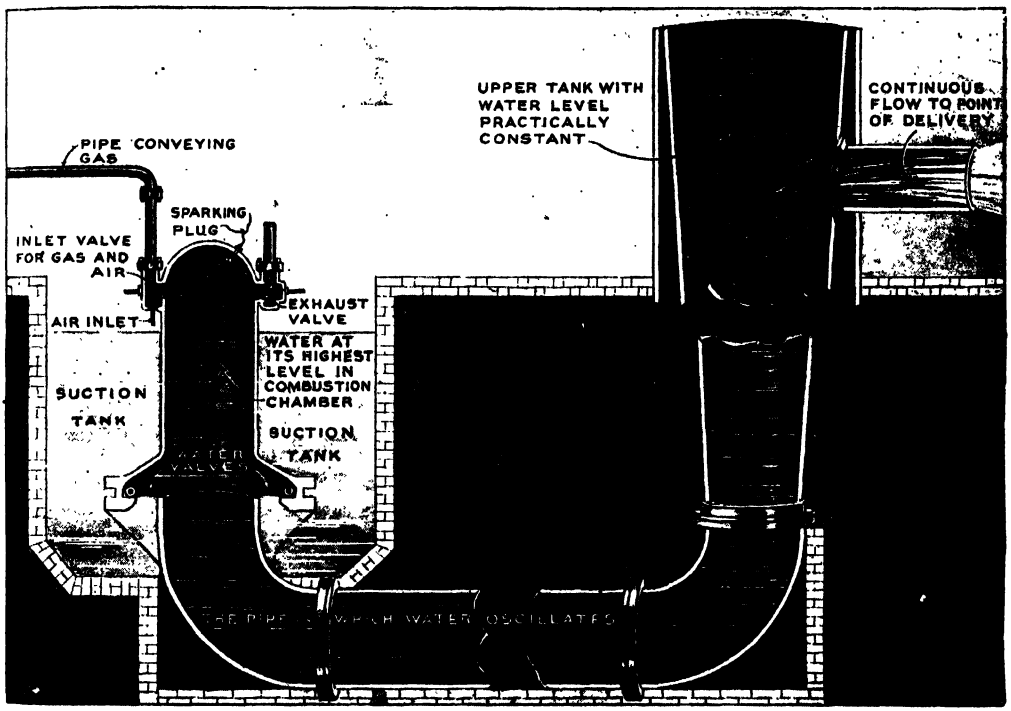
In this example the pump raises the water into the combustion chamber through suction pipes from below. A, air inlet; B, pipe supplying gas; C, sparking apparatus.

This produces a semi-vacuum throughout the upper part of the cylinder, where the valves of the suction tank are. The result is that the water in the suction-tank forces open the valves, and flows into the system. By

this time the water column is losing its forward momentum and the suction valves quietly close. The water swings back from the higher tank, and, in so doing, pushes the spent gas out through the exhaust valve, and then shuts this valve by slapping up against it. Some of the spent gas, however, is unable to escape. It is compressed by the heavy, swinging column of water, and it then acts like a bent spring and rebounds against the water, and drives it downwards once more. Again the water column gathers momentum, leaving a semi-vacuum behind it. This semi-vacuum serves to open the inlet valve, through which the column of retreating water sucks in a charge of gas and air. The water swings back again, compressing the explosive. Then the electric ignition device comes into play, and another swift explosion is produced above the water column, and so the cycle of operations continues.

The method of timing the ignition is very ingenious. A piston works in a small chamber, in connection with the combustion chamber. The little piston is raised by the compression of the charge affected by the last swing upward of the water column. As soon as the water begins to swing downward again, lowering the pressure and allowing the piston to descend, a switching mechanism comes into action and a spark is produced. A very slight fall of pressure is sufficient to bring about the sparking; so ignition takes place at practically the point of highest compression. When the pump is stopped working, it comes to rest with an explosive charge in the combustion-chamber, and can at once be re-started by switching on the electric current and igniting the gas and air.

The pump works with producer-gas, coal-gas, petroleum, or petrol. It is the most efficient internal-combustion motor in existence. For it converts into actual work a greater percentage of the force of the explosion than does any other form of engine. Moreover, its working parts are few and small. There is little to wear, little to lubricate, and little to get out of order. The column of water that surges to and fro under the impetus of the explosion is the principal working part. It is, as it were, the fly-wheel, the piston, connecting-rod, main shaft, and the eccentrics that work the valves. By arranging the pump to deliver water to a large air-vessel, the water under pressure may be utilised to work an ordinary water-turbine, and so drive machinery; and some interesting developments are expected in this direction.



A DIAGRAM OF THE HUMPHREY PUMP AT THE POINT OF HIGHEST COMPRESSION
The connecting pipe and the higher tank are actually twice as long as shown here.

THE TENTED FIELDS OF THE AMERICAN TOBACCO GROWERS OF PORTO RICO

THE RAISING OF TOBACCO PLANTS UNDER CHEESECLOTH—A METHOD THAT INCREASED THE EXPORT OF PORTO RICO CIGARS TENFOLD IN FIVE YEARS

THE TOBACCO INDUSTRY

How the "Holy and Divine Herb" of the New World has been Profaned

GROWTH AND HANDLING OF THE LEAF

"TOBACCO," Mr. Arthur Balfour recently remarked, "has become one of the necessities of existence." It has scarcely been known three hundred and fifty years to the generality of the Old World, but it is said that five and a half million acres of land are now cultivated for the production of the leaf that ends in smoke. A million and a half persons are engaged in making pipes, one town in France turning out forty million clay pipes a year. We Britishers consume about 120 millions of pounds of tobacco every year, and yet we are far from being remarkable smokers. Our tobacco revenue is about one half of the yield of the income tax, being somewhat over £17,000,000. Seeing that the average cost of tobacco is only a halfpenny an ounce, its retail price would be extremely low if it were not taxed for revenue purposes. And in spite of the fact that many of the chief Governments of the civilised world have transformed the general indulgence in the weed into a large source of national profit, and thus increased its price, there has of late years been a great tobacco-hunger, and the demand has outrun the supply. Our tobacco merchants are now paying increased prices to the American planters, and are seeking for new sources of supply. This has opened up a new field of effort for our Colonial planters, and already the tobacco crops of Nyassaland and Rhodesia have become of importance. A little leaf also comes from the Cape and Natal. Canada sends a driblet, and India more. At home, Ireland is producing tobacco, and England and Scotland are experimenting with the crop. So altogether a knowledge of the methods of cultivating and preparing the leaf are likely to be widely useful. Many of our farmers, with suitable lands, might perhaps find the growth of heavy, rank tobacco for the making of insecticides a profitable undertaking.

In regard to the history of this curious industry, there is no truth in the legend that the Chinese cultivated the tobacco plant in ancient times. It was quite unknown throughout the Old World until the sixteenth century, when the Spaniards brought some of the seeds from America. The smoking of the "holy and divine herb," as the great Elizabethan poet Edmund Spenser called it, began as a religious rite among the natives of America. Just as the Delphic priestess of Apollo obtained her inspirations from the fumes of smouldering herbs over which she sat, so the primitive medicine-man of America brooded over a heap of burning tobacco leaves until the narcotic effect of the smoke began to work upon his senses. While inhaling the fumes of the divine herb, he claimed to enter into communication with the spirits, through the stupor produced by the smoke.

But long before the Europeans landed, this primitive method of getting tobacco-drunk was widely replaced by the use of a "tobago." This consisted of a little, hollow, forked cane of a Y-shape, about a span long and as thick as the little finger. The single end was placed amid the burning leaves, and the double end was fixed in the nostrils of the smoker. Then the ordinary pipe was evolved for religious purposes, its two principal forms being the pipe of war and the calumet of peace. Even at the present day there are Red Indians who smoke through their red-stone pipes to the Great Spirit in a solemn act of religious significance. In ordinary practice this became a private affair of daily recreation, in which there was still some dim religious associations and some moral and medicinal intention. Tobacco was

still a holy and divine herb to the Americans, who brought some of it in humble offering to Drake and his companions. So the tradition of its sacredness was carried to England and became immortalised by the author of "The Faerie Queene."

All these savage superstitions had a considerable bearing on the development of the tobacco industry. For though the people of Europe did not, of course, take the holiness of the American herb seriously, they were greatly impressed by the tales of its moral and medicinal properties. It had long been a custom to smoke coltsfoot as a medicine for the throat and lungs, and it was generally supposed that tobacco was a powerful preventive of disease as well as a sedative. Thus, in spite of the fact that a taste for tobacco is more troublesome to acquire than a taste for tea or coffee, the use of it spread with remarkable rapidity in the reign of Queen Elizabeth, and tobacco-shops became as common as taverns. Tobacco then bore a duty of twopence a pound, and the settlers of Virginia found the crops so profitable that they devoted themselves almost entirely to its cultivation. But James I., being the author of the famous "Counterblaste," raised the duty to 6s. 10d. a pound, and restricted the planters of Virginia to a yearly production of a hundred pounds, with the result that the London company of Virginian traders was ruined.

The subjects of the Scottish Solomon, however, continued to smoke more than ever, and by the time of Charles II. the revenue from tobacco duty was helping to fill many a State coffer. It was being cultivated all over Europe and Western Asia, but by an Act of Parliament its growth was forbidden in our country, and discriminating duties were employed to further the interests of the tobacco growers in our American colonies. This was a fortunate thing for the American tobacco planter, for many Governments in the Old World were inclined to follow the plan of Richelieu, and monopolise the national tobacco industry, and turn it into a large and unfailing source of revenue. So the position that the United States still occupies in the cultivation and manufacture of tobacco is largely due to the manner in which American interests were fostered by the Mother Country. Last year we took 104,329,000 pounds of raw tobacco from the United States, and only 14,541,000 pounds from other countries. And this pre-eminence the United States has enjoyed ever since the discovery of tobacco in the sixteenth century.

THE FLOWER OF A TOBACCO PLANT FROM WHICH SEED WILL BE OBTAINED FOR A NEW CROP

At the present time an attempt is being made to cultivate the herb in Ireland and Scotland, and permission has now been given by Mr. Lloyd George for the growth of tobacco in England. Last year Ireland produced 87,907 pounds of cured leaf, while Scotland made a start with 376 pounds. Small as this home industry may now seem, it is not unlikely to develop into a new industry of importance. The Germans manage to grow smoking tobacco in large quantities, and, with a proper system of drainage, the fine fertile soil of our country might be made equally productive. It is true that a good deal of our land is heavy clay, and that the finest qualities of tobacco leaf are grown in light loamy or sandy soils, but the heavy tobacco produced on clay is useful in certain mixtures, and it will probably be found

excellent in manufacturing insecticides. There is a large and growing sale for agricultural preparations of tobacco, which are admirably effective in overcoming blight in apple orchards, and in keeping down other pests that trouble and rob farmers, market-gardeners, and sheep-breeders. A strong, rank English tobacco, grown on a heavy clay soil, might bring a fortune to a man who cultivated it simply for agricultural purposes. On the other hand, we have many fine stretches of the sandy ground that produces the bright Virginia leaf, and a good deal of loam suitable for growing the darker, richer Western leaf of Kentucky that is used in pipe tobaccos. And, having regard to the increasing price of the tobacco leaf, and the low profit of wheat-growing in our country, it is possible that our planters may find the new kind of crop worth experimenting with.

The tobacco plant thrives in nearly every portion of the world, but the American continent, with its virgin soil, its cheap land, and its people trained in its culture, remains today the mother of the industry. Yet the soils of America will soon be no longer virgin, the value of the lands will be higher, and the cost of production will be increased. The settlers in Rhodesia and Nyassaland have already remarked these facts, and begun to cultivate both the American and the Turkish varieties of leaf. Very likely the present war between the Balkan States and the Ottomans will give the Rhodesians a temporary advantage, especially if they profit by it to obtain more seed. Five years ago the Turkish Government tried to prevent them from competing with the Macedonian plantations by forbidding all export of seed, but if the Rhodesians are now alert and enterprising they may be able to obtain all the seed they require.

There are two famous centres of the tobacco industry—the region behind Kavalla, in Macedonia, and the district of Vuelta Abajo, in Cuba, not far from the city of Havana. From Kavalla comes the most delicate and exquisite of cigarette leaves; from Vuelta Abajo the best of all cigar tobaccos. The finest Cuban cigars are called vegueres, and almost equal to these in quality are the regalias. But neither of these is an ordinary article of commerce, for they are exceedingly expensive and limited in quantity. It is also doubtful if the finest Macedonian leaf is of general importance in the tobacco industry, for it is also limited in quantity, and gathered and prepared with exquisite care.

PREPARING SEED-BEDS FOR A TOBACCO CROP IN SOUTH AFRICA

The ordinary commercial Turkish leaf is a blend of Syrian, Asia Minor, Greek, and other growths, bearing about the same relation to the Kavalla leaf as the ordinary Cuban and Florida growths bear to the Vuelta Abajo miracle of delicate and aromatic flavour. In recent years a good

variety of tobacco grown in Sumatra and Borneo has won a position of importance in the best cigar factories. Grown on a volcanic soil beneath the Equator, the fine silky brown tobacco of Sumatra forms excellent cigar wrappers. One company that cultivates it has paid an average dividend of 75 per cent. for many years, and dividends of over 100 per cent. are not unknown. It will thus be seen that there are great prizes in the tobacco industry for planters who study carefully the soil and the climate, and select the variety of seed which experiment shows gives the best result.

Tobacco seed is very small. If it all were to germinate, one ounce would be sufficient for the production of three hundred thousand plants, covering from twenty to seventy acres of land. But, as a matter of fact, a good deal of the seed is infertile, and an ounce of it grows into thirty thousand plants. These are first raised in seedbeds, and planted out at the end of about sixty days.

A TOBACCO LEAF GROWN IN NORFOLK

For ordinary smoking and manufacturing types of tobacco, the plants are set out at distances of three to three and a half feet apart. For the growth of cigar tobaccos the distance between the plants is only a foot to fourteen inches. It is necessary to protect the plants from a wet soil. So, where there is a heavy rainfall, the fields are thrown up in ridges three to three and a half feet apart by means of a plough, and the tobacco is planted on the top of the ridges. This would probably be found the best way of growing tobacco in England.

The Americans reckon a man and a boy can plant out five thousand plants a day, with another lad to do the watering. But transplanting machines are now coming largely into use. These machines set the plants at the required distances and water them in a single operation. If desired, they will also place a small quantity of fertiliser with each plant. Three persons are required to handle a machine—one to drive the two horses, and the others to feed the machine with the plants. Five acres of ordinary tobacco may thus be planted in a day. During growth the tobacco needs fine cultivation, and the hoe must be continually used to kill the grass and weeds, and to keep the soil from hardening and crusting over. For the tobacco plant is a surface feeder; its roots do not penetrate deeply in the ground. Hence the soil must be well stirred to bring about the rapid growth that produces the fine, even texture of the best kind of leaf.

The seed of the plant is produced at the expense of the leaf. So, except in the case of a few plants selected for seed production, it is necessary to top the tobacco when the flower buds appear. The plant then throw out shoots or suckers, and these have also to be broken off. As the plant ripens, it changes in colour from a dark to a lighter green, and cracks when folded between the fingers.

Unfortunately, all the leaves do not ripen at the same time. So the finest tobacco is obtained by gathering each leaf as it ripens. But in harvesting the bulk of American tobacco the whole plant is cut from the stalk when the middle leaves are mature. The plants are cut off at the surface of the ground with one stroke of the knife, and strung on curing-sticks. These are about four feet long, with a detachable iron spear-head at one end. When filled, the sticks are carried to the curing-barn, where the green leaf is manufactured into tobacco.

The old method of sun-curing is now but little used, except in a small part of Virginia, where some poor farmers carry on the traditional method, for the reason that they cannot afford to build curing-barns. They hang the tobacco on racks in the sun, but shade it to prevent sun-burning. On the approach of a storm, all the tobacco has to be carried under shelter to prevent it getting wet. Moreover, this old-fashioned

TOBACCO PLANTS IN ENGLAND AND IN CUBA

SIX-FOOT TOBACCO PLANTS ON THE NORFOLK EXPERIMENTAL FARM

A TYPICAL TOBACCO PLANTATION IN THE PROVINCE OF HAVANA, CUBA

way of curing the plant makes the leaf sweet and sugary, and the presence of a large quantity of sugar in the tobacco renders it very liable to become mouldy. The production is small, and the tobacco is so sweet that it is chewed instead of smoked.

The greater part of tobacco shipped to Europe and Africa is fire-cured. The gathered plants are allowed to hang from the curing-sticks until they turn to a rich yellow colour. Small open wood fires are then lighted on the floor of the barn under the hanging plants, which are cured, like hams, by the heat and the smoke. The fire is kept burning for four or five days, until the tobacco is dry. But even then the stem will be full of moisture, and as soon as the heat is lowered the water will spread into the leaves and make them soft. So the fire is again lighted, and the drying process is repeated whenever the leaf shows a tendency to become soft. The second drying is particularly necessary if the lighter shades are desired in the leaf; and the curing process must always be gradual, for if the heat rises too soon or too rapidly it will cook the tobacco and give it a bluish tinge.

In flue-curing the smoke does not come into contact with the tobacco. The fires are lighted in small brick furnaces on the outside of the building, and the heat is carried under the tobacco by means of large sheet-iron pipes. This is the system that produces the yellow tobacco which has become popular for cigarettes and pipe mixtures. It needs more judgment and skill than the other methods, for a little mistake in maintaining a certain temperature too long or too short a time will alter the shade of colour and greatly lessen the value of the leaf. The leaf is first yellowed by a mild heat lasting from eighteen to twenty hours. The colour is then fixed by maintaining a higher heat for the same period. Then the leaf is killed by another increase of temperature that lasts for two days. At the end of this time the leaf is so dry that it will crumple to powder in the hand. If the tobacco is being cured on the stalk, a fourth stage of curing is necessary. This is known as killing the stalk. The heat is again increased at a regular rate to about 175 degrees, until all the sap in the stalk is thoroughly dried out. If this is not done, the sap will spread into the leaves and form red veins in them.

HOMING THE HARVEST OF TOBACCO LEAVES ON THE NORFOLK EXPERIMENTAL FARM

In flue-curing, the moisture begins to ooze from the leaves at the temperature of 110 degrees. This sweating carries out of the plant many disagreeable substances that would be harmful to the quality of the tobacco. As soon as the leaf is cured, the fires are extinguished and the doors and ventilators of the barn are opened. The moisture of the air then affects the and diminish the value of the leaf, besides making it liable to moulds. It pays to store tobacco after it has been cured. For, at the end of two years, its quality and value are increased.

All cigar tobaccos are air-cured; and so is the White Burley leaf grown in the light loam of Kentucky. Any tobacco may be air-cured, though, of course, the

CUTTING THE TOBACCO CROP AND HANGING IT TO DRY AT MONTPELLIER, JAMAICA, ONE OF THE LARGEST PLANTATIONS IN THE WORLD

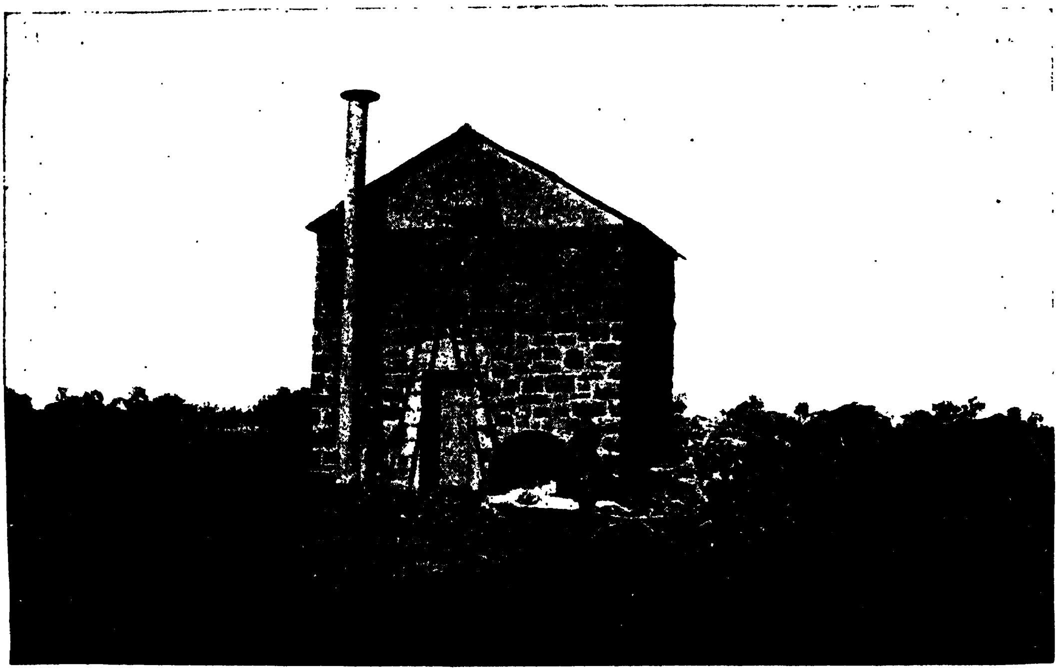
leaf, and prevents it from crumbling into powder when handled. The tobacco is next hung in the packing-house. Later in the season it is taken down and graded and tied into "hands," and again re-hung, or bulked, until the grower wishes to market it. But care must always be taken that it does not become too moist, for an excess of moisture would darken the colour

yellow colour can only be produced by the application of heat. The White Burley is cured on the stalk. It is wilted and hung in the barn in the same manner as other stalk-cured tobaccos. The process lasts about six weeks, and consists in regulating the temperature and moisture of the air in the barn by means of ventilators. If the leaf is drying too rapidly, the ventilators

are opened on moist days and nights, and closed in dry weather. If the tobacco is slow in drying, the ventilators are kept open on dry days. In wet weather a charcoal fire or a stove may have to be lighted.

Most kinds of cigar leaf are dried on the stalk, but some varieties ripen unevenly, so the leaves are gathered singly, and strung back to back on twine, to prevent them folding round each other and drying unequally. The labour of plucking the leaves singly is also required in the case of fine tobacco used for cigar wrappers. For here slight differences in the ripeness of the leaf would be disastrous. It was recently supposed that microbes played an important part in the air-curing process. An attempt was even made to impart the flavour of fine Havana leaf to inferior tobacco by introducing some Havana bacteria into the curing-shed. But this theory is now completely exploded. Microbes do not take in tobacco-curing the part they play in cheese-making. The fermentation of the tobacco leaf is produced by a fermenting substance in the leaf itself. This fermenting substance is called an enzyme.

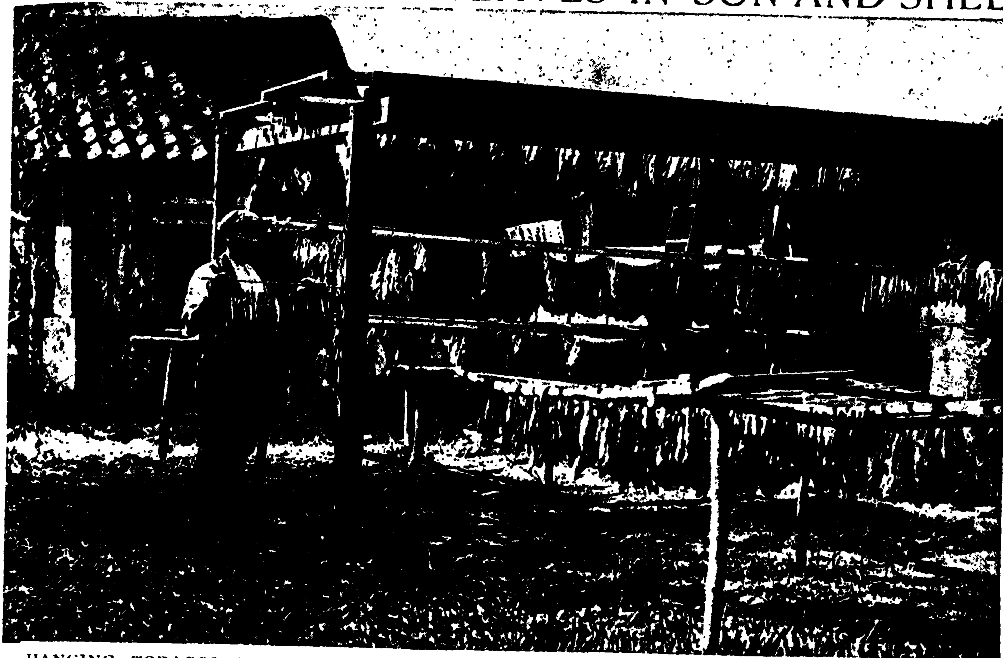
An enzyme is a glue-like form of matter, which is destroyed by boiling. In its action it somewhat resembles certain chemicals known as catalysers. An infinitesimal amount of platinum will cause a large mixture of oxygen and hydrogen to explode; and common coal gas bursts into flame when brought into contact with a minute amount of platinum. There are mineral acids that transform starch into grape sugar by their catalytic action. One part of a catalyser may transform millions of parts of the substance that it acts on. Moreover, the quantity of the catalyser does not diminish during its action. Brought into contact with another mass of changing substance, it continues to produce its extraordinary result. Now, an enzyme seems to be a kind of organic catalyser. It is a chemical, or a combination of chemicals, existing in the tissues of plants and animals and men; and its function is to break up food compounds and reduce them to substances which can be absorbed by the living cells.



A FLUE-CURING TOBACCO-BARN IN SOUTH AFRICA, SHOWING THE OUTSIDE GRATE AND VENTILATORS

It must clearly be understood that an enzyme is not a living thing, like a microbe, but merely a subtle chemical, elaborated by the cells of plants and animals to help them in their work of assimilation. Practically all the main processes of respiration, digestion, and the building up and breaking down of living matter is performed by the enzymes of the cells. Even microbes cannot act otherwise than by the production of substances which must be regarded as enzymes. In fact, all the processes which were formerly

CURING TOBACCO LEAVES IN SUN AND SHED



HANGING TOBACCO LEAVES IN THE OPEN AIR AT THE NORFOLK EXPERIMENTAL FARM

THE INTERIOR OF A TOBACCO LEAF DRYING-SHED IN JAMAICA

believed to be exclusively connected with living protoplasm are recognised as being due to the presence of glue-like compounds with a curious catalytic power.

Now, in the tobacco plant there are enzymes which have the power of taking oxygen from the air and supplying it to the cells, thus causing the splitting up of existing chemical compounds and the creation of new products. When the plant is gradually starving to death, on being cut and allowed slowly to dry, there is a rapid formation of the enzyme substances. They separate themselves from the protoplasm of the cells, and push out through the plant in search of oxygen for the dying cells. But unless the leaf is killed by heat, or by rapid drying, the enzymes are unable to escape from the protoplasm. So, when the unkilled leaf is moistened, the fermentation the enzymes produce will be a partial or a total failure.

So the leaf must be killed to liberate its chemical ferments. When this is done, the ferments will act in a very powerful manner as soon as the dead leaf is moistened. Such is the curious, scientific explanation of the methods of curing and fermenting tobacco which have been worked out by practical experience. It is now easy to see the reason why great skill and judgment are necessary in drying tobacco leaf by artificial heat. The temperature must be sufficient to kill the cells slowly, and incite them to elaborate an abundance of enzymes. On the other hand, the heat must not be so great as to destroy the powers of the fermenting substances. For if this is done there will be no fermentation, and all the chemical changes in the leaf which develop the aroma and get rid of its undesirable products will not take place. The first process of curing increases and liberates the enzymes. The second process, known as the fermentation or sweat, sets the enzymes working. And if the third process, known as ageing, is employed, there is a mild continuation of the action of the fermenting compounds.

Thus it is absolutely impossible to inoculate an inferior tobacco with the fermenting agents of the finest leaf. Not only do microbes play no part in the process of tobacco manufacture, but the fermenting leaves are destructive of bacterial life. The qualities of the prepared leaf are due entirely to the action of chemical substances secreted by the cells; and the qualities of these fermenting substances are directly related to the conditions under which the plant is grown—soil, climate, weather, method of cultivation, and so on.

In fine cigar leaf, the after-fermentation is of great importance, and the curing process is designed to develop the enzymes as much as possible. So long as the cells of the plant are alive—and if properly handled they will remain alive for several weeks—there is a movement of organic matter from the tissue cells to the rib cells; and the starch in the form of sugar is largely transported and consumed by the processes of respiration. So in curing cigar leaf the endeavour is to get it dry, and bring it back into a moist condition once in twenty-four hours. This alternate drying and

A KOREAN ARRANGING PARCELS OF TOBACCO FOR THE MARKET

moistening induces the movement of the contents of the ribs out into the body of the leaf. The longer the ribs and the stem are kept alive, the greater will be the quantity of fertilising substances formed by this curing process. Yet if the curing is ascertaining whether the fermentation was properly proceeding or not.

At the present day the method of bulk fermentation is employed by progressive men. The leaves are first sorted into three classes, according to colour and texture,

A PILE OF LIQUORICE-ROOTS, USED IN THE MANUFACTURE OF SWEET TOBACCO AT ALEPPO

protracted over too long a time, the leaf will lose its elasticity and strength.

On the ability of the leaf to ferment properly, and on the skill of the man charged with regulating the fermentation, depend the quality of the finished product. The planter is not usually in a position to give full attention to this work, and as a rule he does not possess buildings where the correct heat and moisture conditions can be maintained. So the process is often conducted by dealers, who ferment hundreds of thousands of pounds of tobacco every season. Several different methods are practised.

In that which was most largely used till recently, the tobacco was packed in wooden cases, each containing about three hundred pounds of leaf. By means of a screw or lever the box was pressed down moderately tight, and as much air as possible was excluded. It was then placed in a room kept at an even temperature. There the tobacco remained for a summer, while the moisture and other products of the fermentation oozed out of the case through openings made for the purpose between the boards. At times the cases were placed in heated rooms, and the fermentation forced. But the method was not satisfactory. The tobacco could not be observed in the wooden cases, and there was no means of

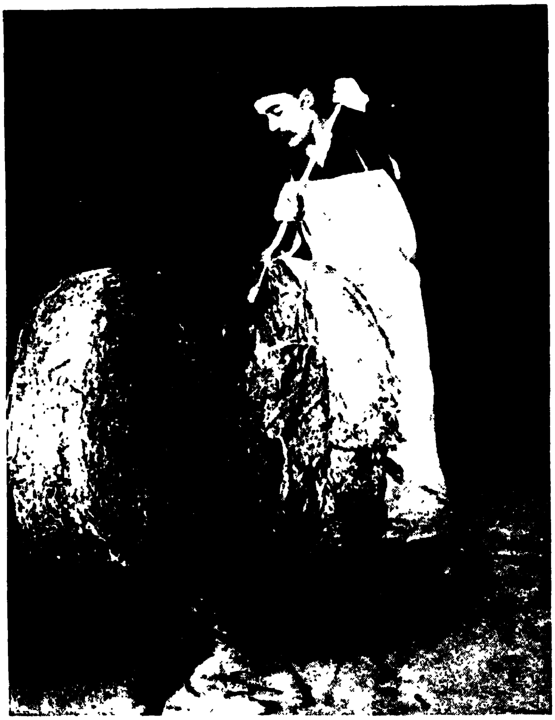
and each class is treated differently, according to the nature of the finished product desired. Just now, for instance, there is a demand for light shades in the wrapper leaves. So these must not be given as heavy a fermentation as the tobacco used for the fillings of cigars. For if this were done their colour would grow very dark. When graded, the leaves are stacked in separate masses. From three to five thousand pounds of the lighter tobaccos are allowed to a bulk. In the medium grades eight to ten thousand pounds are fermented together; while three times this amount of filler leaves is put in bulk. A bulk is from from four to five [illegible] wide, from four to eight feet high, [illegible] placed on a plat[illegible] above the floor [illegible] steam, and kept at [illegible] 75 to 80 degrees [illegible] with canvas, blank[illegible] or rubber sheeting; and in a short [illegible] it will begin to grow warm as it ferm[illegible] till the temperature reaches 130 deg[illegible]

When this [illegible] the bulk must be rapidly brok[illegible] the fermenter and his assistant[illegible] rebuilt. Quick and skilful handl[illegible]ecessary, and a large staff is need[illegible] event thirty thousand pounds of t[illegible]om being ruined. The

process of rebulking may have to be repeated six or eight times, until the finest aroma possible to be obtained from the tobacco is elaborated by the enzymes. But if the process is carried too far, all the fine qualities may be destroyed, and the tobacco reduced to something about as valuable for smoking purposes as old rags or paper. On the other hand, the fermentation may be retarded by the dryness of the leaf. In this case steam is let into the room, or a fine spray of water is scattered on the atmosphere by means of a compressed air machine.

Expert fermenters judge the condition of a pile of leaves by thrusting their arm into it. But an accurate thermometer, inserted in a perforated tin cylinder, is the most reliable of instruments. In the low-grade tobaccos used for the fillings of cigars, the fermentation is stopped before its completion, and the leaves are treated with a "petuning." This consists of two gallons of rum, a gallon of sour wine, half a pint of valerian tincture, two quarts of black coffee, two pounds of liquorice paste, and one ounce each of aniseed oil, powdered cloves, and powdered cinnamon, together with sufficient water to make five gallons. The curious mixture is sprayed on each layer of leaves, with the idea of communicating to the tobacco an artificial aroma resembling that of the best Cuban leaf. This petuning, however, is never done to first-class tobacco. So, when one is about it, it is well to buy a good cigar from a well-known factory. If one cannot afford this, it is wisest to keep to a pipe and a sound smoking mixture.

On the completion of the fermentation process, the tobacco is ready to be graded and packed for shipment. Leaves of the finer qualities are very closely sorted and very carefully handled. The best grades of Cuban leaf are made into "hands" o forty leaves each, and four hands are boun together with bast into a carrotte, weighin about a pound. Eighty carrottes are the combined into a bale, which is pressed int shape in a press and covered with canvas over which is placed the inside bark c a Cuban tree. Only leaves of the fines quality are made into carrottes. Second grade leaves are given a second thoroug fermentation, and stemmed, smoothed, an flattened out, and made into what is know as a book of fillers. These books are the combined into bales. The bales of the bes wrappers, where no further fermentatio is desired, are place in a cool room. The are stood on end, an reversed every othe day for several weeks When dry, they ar piled one upon th other, and thre months after balin they are fit for us by cigar-makers. Th fillers are placed in warm room, wher they slightly fermen for six months befor they are ready fo immediate use.



OPENING A BALE OF TOBACCO LEAVES

After a tobacc has been cured, i must go through process of ageing But as this is a mil fermentation, wel fermented leaves re quire less of it tha ordinary unfer mented tobacc Smoking tobaccos ar allowed to age for a least two years, an the process is often continued for four or fiv years. It is the cost of all this handling an storing that makes a fine ripe smoking mix ture dearer than some quickly finished pro duct. But the ageing cannot be continue indefinitely. In the sixth year a deteriora tion of quality is more likely to take plac than a further improvement. Ageing partly a process of slow fermentation an partly an oxidisation of the leaf substance without the agency of the fermentiv enzymes. It softens and mellows a tobacc taking away its rawness and bitterness, a well as any disagreeable odour, and im proving both the aroma and the burnin

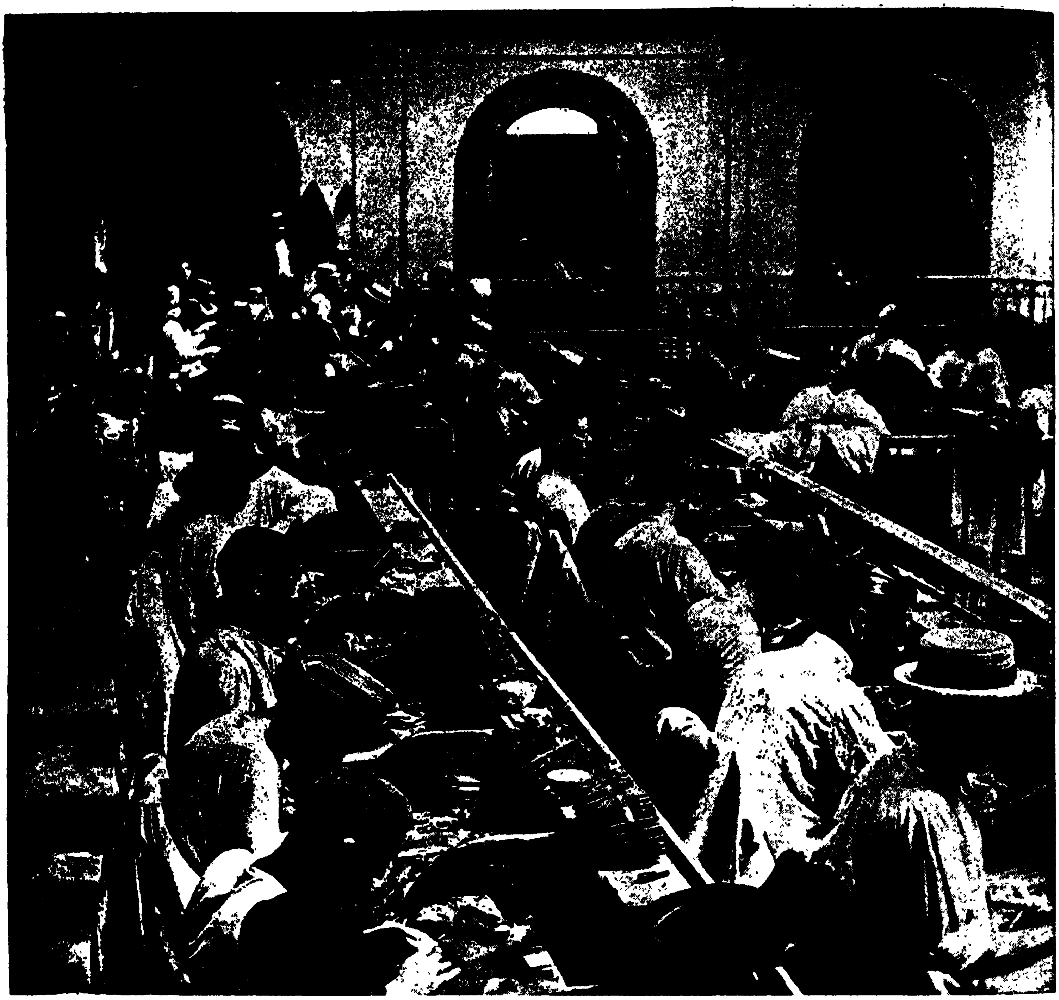
qualities of the leaf. Now that an attempt is being made to market Irish and Scottish tobaccos, it is most necessary that the leaves should not be sold until they have been thoroughly aged, or they will be so raw, strong, and disagreeable that they will get a bad name, and the planters now experimenting with them will find it difficult to dispose of their future crops at a profit.

All ordinary tobaccos are packed in hogsheads, containing from six hundred pounds of the lightest leaf to sixteen hundred or two thousand pounds of the very dark leaf. In some cases hydraulic pressure is used to compress the tobacco at intervals while filling the cask. But more usually a screw worked by steam or hand-power is employed. Intense pressure causes the tobacco to darken. This is why there is less of the light yellow leaf to a hogshead than there is of the dark tobacco. American tobacco intended for the English market is packed as dry as possible, because of the high duty levied on this import. In many cases the weight is further reduced by the removal of the stems.

America is, of course, the great tobacco mart of the world. Each town in the tobacco-belt has large warehouses for the sale of loose tobacco. Waggons are drawn in on to the floor by the farmers, and each man's tobacco is quickly unloaded and weighed, and placed in a pile by itself. The auctioneer passes rapidly from pile to pile, amid a crowd of buyers crying their bids. Each buyer on making a purchase brings in his waggon, and quickly loads it with the pile he has bought, so that almost as soon as the last pile is sold the warehouse is cleared of tobacco and ready to be filled again. During the busy season the sales sometimes continue from early morning till late at night, and one warehouse will sell as much as sixty thousand pounds in a day. At Danville, a Virginian town with nine warehouses, fifty million pounds of loose tobacco have been sold in a season.

A sale is only a matter of seconds. So the buyers, who are representatives of manufacturers, exporters, and speculators, need a rapid power of judgment. They go by sight, touch, and smell. They observe the length and width of the leaf with their eyes and scan it for moulds. They tell its texture by feeling it with the hand, and stretch it to measure its elasticity. Naturally, the odour is important, and it is necessary to determine the amount of moisture, which, if in excess, adds a great amount of unprofitable waste. The buyers also examine if the tobacco is uniform in quality. The struggle between the buyers in the bidding is sometimes very dramatic. Some of them at times will combine

STRIPPING TOBACCO LEAVES AFTER THEY HAVE ARRIVED IN BALES AT AN ENGLISH FACTORY



CUBAN CIGAR-MAKERS AT WORK IN ONE OF THE LARGEST FACTORIES IN HAVANA

together, and attempt to control prices; and rival firms will run the bids up very high against each other, so as to lessen each other's margin of profit on the finished product. The warehouseman requires full settlement from the buyers during the day of the sale, and any defaulter is refused further privileges on the market. As soon as the sale is over, the farmer is entitled to a cheque from the warehouseman for the amount due to him, less a small fee for warehousing and weighing, and a commission of 2½ per cent. from the sales.

In our country, the various kinds of imported tobacco are stored in bonded warehouses under the careful supervision of the Customs Department. There is often 200 million pounds in bond, worth £7,000,000 to its owners, and a good deal more than five times that sum in taxes to the Crown. So naturally it is jealously guarded by the Government officials. Some of it is manufactured in bonded factories into cigarettes and pipe tobaccos for export. About fourteen and half million pounds of leaf are dealt with in this way. A small export trade is also carried on by licensed manufacturers, who pay duty on the tobacco and then get it returned when the goods are sent abroad for sale. But all this export of manufactured tobacco is of small importance when compared with the home industries connected with the duty-paid leaf. Our people consume about 67,500,000 pounds of pipe tobacco; somewhat under 24,000,000 of cigarettes; nearly 5,000,000 of cigars, and not quite 1,500,000 pounds of snuff. Thus there are nearly three times more pipe-smokers than cigarette-smokers: nearly five more times cigarette-

ROWS OF CIGARETTE-MAKING MACHINES IN A FACTORY IN MEXICO CITY

smokers than cigar-smokers, and over three times more cigar-smokers than snuff-takers.

The British cigar trade, moreover, is three times greater than the foreign trade. The best cigars are made entirely by hand, in quite a simple way. The maker takes in his left hand some pieces of filler tobacco, roughly arranged in the shape and size of the cigar he is making. He places on them a piece of bunch wrapper, and then rolls the fillers into a bunch. Round this he carefully places a fine, thin wrapper leaf, cut to the exact shape of the cigar. Just a touch of gum of a tasteless and colourless kind, on the point where the wrapper is tucked in, is used to prevent unwrapping. This is how the best cigars are made. In cheaper and more quickly made varieties, the bunch is rolled in the ordinary way, and then shaped by being pressed in a mould. When set, the bunch is taken from the mould, and covered with a wrapper leaf. Moulded cigars can be usually distinguished by the two long ridges running down the whole of their length. They are produced through the bunch wrapper being slightly caught between the two sections of the mould when pressed together. There has lately been a marked improvement in the quality of British-made cigars; and though they cannot, of course, compete with the fine and very expensive cigars made from Vuelto Abajo leaf, yet for cheapness combined with fair qualities they are very hard to beat.

In pipe mixtures, the public is also well served by our manufacturers. The cheap forms of cut tobacco sell at 4s. 8d. a pound, of which 3s. 8d. is revenue duty. This leaves 12d. to be shared between growers, warehousemen, shippers, merchants, and

MAKING CIGARS BY HAND IN BURMAH

BURMESE WOMEN CUTTING AND ROLLING THE WRAPPERS FOR CIGARS

NATIVE WOMEN ROLLING LEAF TOBACCO INTO CIGARS AT MOPOON, BURMAH

retailers. The grower takes about two-thirds, the cost of warehousing and transport absorb most of the remaining 4d., and the manufacturers' and retailers' profit is largely derived from the moisture imparted to the leaf during the process of manufacture. The legal limit of moisture is 32 per cent.; and as competition is so keen, this proportion is generally kept as near as possible to the margin of safety. On the other hand, no other form of adulteration is now practised in the British tobacco industry

A good many pipe tobaccos are first steamed to make them moist, then spread out on hot metal plates, and placed on trays to cool. This is usually done after the leaf has been cut in a guillotine machine, by a mechanically driven knife, capable of being set to cut coarse or fine according to requirements. Flaked tobaccos, however, are formed by placing the large moistened leaves in a hydraulic box-press, that converts the tobacco into a hard slab about one and a half inches thick. The slabs are cut into bars, and the bars are cut into thin sections or flakes. In bird's-eye tobacco, some of the stalks are left on; and from their finely cut sections, with their rather vague resemblance to a bird's eye, this kind of tobacco gets its name.

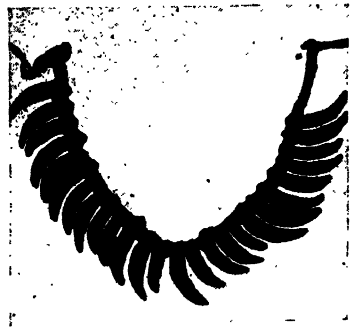
The process of manufacturing cigarette tobacco is very simple. The leaf is damped to make it pliable, and is then stripped of its midrib, if it comes from America, Turkish leaf being too small to need stripping. It is passed through a cutting-machine, which is set to cut it fine, and the cut tobacco is lightly heated to remove the excess of moisture, and to bring out the aroma. It then needs only to be covered with paper.

In hand-made cigarettes, the paper tubes or spills are first rolled and gummed down or crimped, and then the tobacco is rolled up in a piece of parchment, and pushed with a little piece of stick into the rolled parchment or spill. In the cigarette-making machine, 550 cigarettes a minute are made. A mile of paper unrolls from a disc; and as it moves, an ingenious little printing device stamps upon it, at short, regular intervals, the name of the brand and the maker. The paper is met by the tobacco fed into the machine, and then rolled sideways and stuck at the edge, producing, as it were, one unending cigarette. This is cut by a small guillotine, working with almost invisible rapidity, into even lengths, forming the finished cigarettes. As they fall out, a girl stacks them in trays ready for packing. But there is another machine, now largely used, that cuts out covers from thin cardboard, counts out ten cigarettes, adds a little picture-card, and then delivers the packet closed and complete. It is about twenty-five years since the first cigarette-machine was exhibited in London. It has completely revolutionised the cigarette industry, and created a new demand for the articles it supplies. Whether this is altogether an improvement in other directions—say, in the matter of the national health—is another matter.

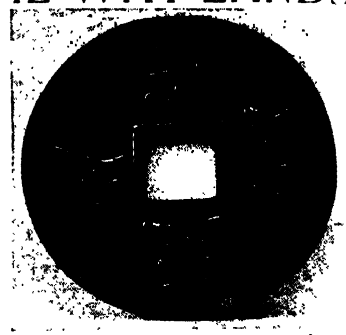
TRIMMING THE ENDS OF FINISHED CIGARS AND PACKING THEM INTO BUNDLES AT MANILA
The photograph on page 3869 is by courtesy of Messrs. R. & J. Hill; others by the H. C. White Co. and Underwood and Underwood.

STRANGE COINS OF OUT-OF-THE-WAY LANDS

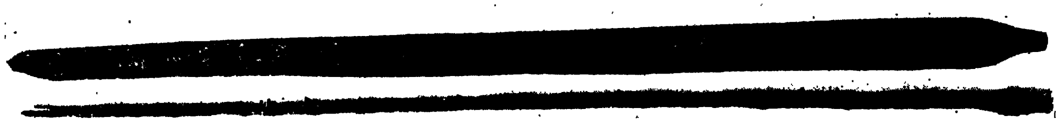
AFRICAN RING-MONEY



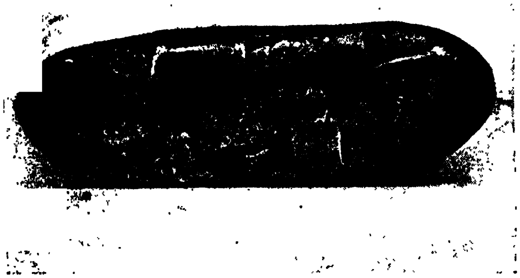
SHARK'S TEETH, NEW GUINEA



LARGE CHINESE "CASH"



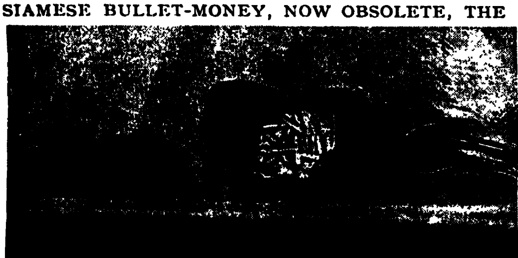
ANCIENT BRITISH SWORD OR IRON CURRENCY BARS, REFERRED TO IN CÆSAR'S COMMENTARIES



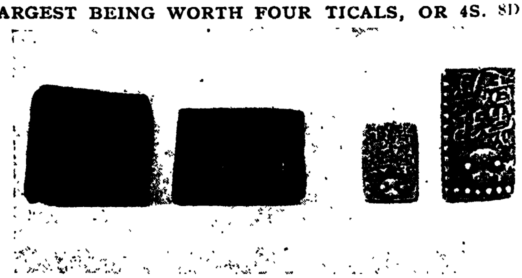
COCHIN CHINA SILVER WILLOW-LEAF

CHINESE SILVER BRACELET-MONEY

SIAMESE BULLET-MONEY, NOW OBSOLETE, THE LARGEST BEING WORTH FOUR TICALS, OR 4S. 8D.



LONGBIT OF HASSA, ARABIA, OF A.D. 920; CHINESE SILVER BOAT; AND CEYLON FISH-HOOK MONEY



SWEDISH KLIPPES OF A.D. 1611-1632, AND TWO JAPANESE SILVER "SQUARE" COINS OF A.D. 1772

THE MYSTERY OF MONEY

How Goods are Exchanged Without Money Really Passing. The Use of Cheques and Bills of Exchange.

THE ENORMOUS EDIFICE OF CREDIT

At the very beginning of our study of commerce we saw how great was the step which Man made when he attained to the conception of a common standard of value in order to facilitate his exchanges. Our earliest picture of trading man is of a rude savage exchanging a weapon for an ornament. Barter must have continued for an exceedingly long period—long, that is, as mundane beings must reckon time—before it became even possible to agree to the value of all goods in terms of one particular commodity, and thus to arrive at money. As we saw in the last chapter, value is purely a relative thing; for convenience' sake, we select one convenient commodity, and relate all values to it.

Barter still exists in the world in remote regions where civilisation has scarcely appeared. There are places in the interior of South Africa and South America where still we may take with us stocks of beads and other ornaments, knives, mirrors, etc., and perform with them the most elementary operations of barter. Even in our own country a paper is still published which devotes itself to advertisements of persons who desire to exchange things with each other. It may be usefully noted, however, that with regard to these British exchanges those who carry them on barter with the conception of a common standard of value in their minds. For example, if an advertiser offers a camera in exchange for a bicycle, he will point out to applicants that the camera cost so much, and equally he will expect a bicycle which cost so much. When such an exchange takes place, therefore, the use of money is in the minds of the barterers, and helps them to effect a fair exchange.

The two main functions of money should be carefully borne in mind—first, that it is a *standard or measure of value;* and second, that it is a *medium of exchange.* As a standard of value, its uses pass enumeration; as a medium of exchange, the use of actual coins is very limited. We have always the standard coin in mind when we measure values, when, that is, we express exchange value in price, but when it comes to actual exchange we do not use actual coins at all, save in small transactions, but use *bits of paper on which we have written promises to pay in terms of the standard of value.*

We must be careful not to confuse money with wealth. A coin made of rare metal is an instance of wealth, but only one instance. The greater part of wealth, of course, exists in other forms. When a man says that he wants plenty of money, what he really means is that he wants plenty of wealth, and he is imaging that wealth by relation to the common standard of value.

We choose for use as a standard of value and medium of exchange a commodity of some rarity, which has considerable stability of value, which has qualities of permanence, which is divisible, which is generally acceptable, and which is portable. Gold conspicuously conforms with these various requirements, and for that reason it has easily beaten all other commodities as a standard of value. Gold is a rare metal that has considerable stability of value; it is not indestructible, but it is to a great degree permanent under ordinary conditions; it is homogeneous in composition, and is therefore divisible, losing none of its value through a division into any number of parts; its inherent qualities make it generally desirable and acceptable; and, as a small quantity of it has a high exchange value, coins made from it are easily portable.

Of the qualities named, stability of exchange value is not the least. This will be realised if we imagine some commodity of rapidly fluctuating value to be used as

money. Suppose we used indiarubber or wheat as a standard of value. These articles are constantly varying in price. It would be very difficult, therefore, to make time bargains in terms of them. We should feel great diffidence in entering into a bargain to pay for an indefinite period interest in wheat, for in ten years' time wheat might be twice as scarce or twice as plentiful as now, and we should be entering into a very great risk. Similarly with indiarubber. In ten years' time indiarubber might be so very much more plentiful than now that if a man agreed to take payment in indiarubber twenty years hence he might be entering into a very poor bargain.

We need not be surprised, then, that gold, possessing the desirable qualities named, as no other substance does, except platinum—and platinum has now twice the value of gold—has won its way to be the recognised standard of value in most of the countries of the world, and that its use as a standard is always extending.

It is necessary here to point out that the small silver, nickel, or copper coins which are used in gold-standard countries such as the United Kingdom are merely tokens, and coined for convenience in connection with very small transactions. They are not legal tender beyond a certain low level. Our bronze coins, for example, cannot be legally tendered as payment of sums exceeding one shilling, and silver coins cannot be legally used for the payment of sums of over two pounds. That is to say, if we owe a tradesman ten pounds, he can, if he likes, accept ten pounds' worth of silver coins, but he has the legal right to refuse them, and to demand gold for that part of the sum which exceeds two pounds. The same is true of the nickel and other small coinages of the Continent of Europe; they are not legal tender for more than very small sums. It may be remarked, in passing, that the introduction of nickel token money in substitution for our bronze would be a reform of much value; nickel is both more convenient and more cleanly than the too familiar "copper."

In the table below we give a statement of the chief coins of the money of the chief foreign countries. In no country except the United Kingdom is so valuable a coin as the sovereign used for the expression of common values, but it should not be thought, because a Frenchman normally expresses prices in francs and the German in marks, that the silver franc and the silver mark are expressions of a silver standard. Like our own shillings and florins, these coins are tokens which are not legal tender for more than a certain small sum. The actual standards of these countries are expressed in gold. For example, in France the twenty-franc piece weighs 99·563 grains, and contains 89·607 grains of pure gold. Similarly, in Germany silver coins cannot be legally tendered in payment of sums exceeding the value of twenty marks, and a definite number of ten-mark pieces is coined out of a German pound weight of fine gold to fix the standard.

Certain of the Continetal countries, viz., France, Italy, Belgium, and Switzerland, entered, in 1865, into a currency union—the Latin Union—which still exists, and is of considerable international value and importance in relation to trade.

MONEY OF THE CHIEF FOREIGN COUNTRIES.

Country.	Chief Coin.	Value in £ Sterling.
		s. *d.*
German Empire	Mark	0 11·8 *i.e.*, about 1s.
France	Franc	0 9·6 *or* 25 to the £
United States	Dollar	4 2 *i.e.*, about 5 to the £
Russia	Rouble	2 1⅓ —
Italy	Lira	0 9 6/10 *or* 25 to the £
Austria	Krone	0 10 *or* 24 to the £
Hungary	Korona	0 10 *or* 24 to the £
Spain	Peseta	0 9 6/10 *or* 25 to the £
Portugal	Milreis	4 6 —
Belgium	Franc	0 9 6/10 *or* 25 to the £
Holland	Gulden	1 8 *or* 12 to the £
Sweden	Krona	1 1⅓ *or* 18 *to the* £
Denmark	Krone	1 1⅓ *or* 18 to the £
Switzerland	Franc	0 9 6/10 *or* 25 to the £
Bulgaria	Leu	0 9 6/10 *or* 25 to the £
Turkey	Piastre	0 2·16 100 piastres equals 18s
Japan	Yen	2 0½ —
Argentina	Peso (Gold)	4 0 —
Brazil	Milreis	2 3 —
Chile	Peso (Gold)	1 6 —

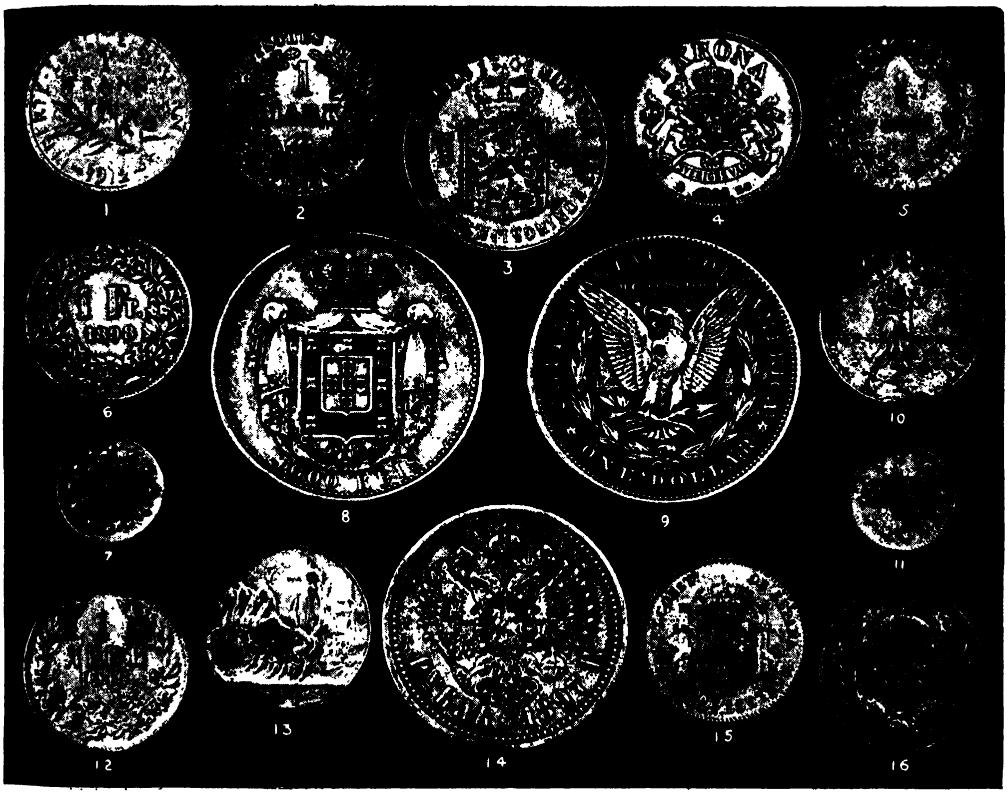
It will be noticed that in our table the value of the unit coin of these four countries is the same. Each of the nations binds itself by treaty to recognise and to receive the legal tender coins of the others. Their coins, the franc of France, Belgium and Switzerland and the lira of Italy, are money of the same weight and fineness of metal, so that they are exchangeable the one for the other. The great convenience of this union has been recognised by other countries, and Spain and the three chief Balkan States—Bulgaria, Servia, and Roumania—have conformed to the Latin Union's system, although they are not members of it. Thus the leu of Bulgaria

is of the same weight and fineness as the franc of France or the lira of Italy.

It should be noted that the values given in the table in English currency are approximate values.

The principle of the gold standard rests upon the common-sense consideration that it is best to have one single standard of value. This will be obvious from consideration of the fact that, as value is relative, the adoption of a double standard of value must create confusion and uncertainty. If we can imagine gold and silver always maintaining the same relative value to each other, then a double standard, or bi-metallism, would be a practical possibility. As a matter of fact, however, gold and silver are constantly changing in their value relatively to each other, and a bi-metallic standard, therefore, is an economic absurdity. It is not possible for the Government of any State to fix an arbitrary standard between the values of gold and silver which is of the slightest practical value. If there were a natural constant ratio between the values of the two metals, there would be no difficulty. As there is no such constant ratio, there is inherent and insuperable difficulty.

We have said that gold is comparatively stable in value, but, while that is true, we must guard ourselves against the idea that gold is fixed in value. Like any other commodity, its value relatively to any second commodity must rise and fall. The idea that the value of gold never varies is quite a delusion. What gives rise to the idea of a fixed value for gold is easily explained. The London Mint is compelled by law to mint into sovereigns any gold that is brought to it, at the rate of £3 17s. 10½d. per ounce. But that merely expresses the fact that the standard coin we call a sovereign is equivalent to the quantity of gold which the law dictates that it must contain. What is done at the Mint is to take forty pounds' weight of gold of the standard fineness—*i.e.*, 916·6 per 1000 parts—and to mint from it exactly 1869 coins, which are called sovereigns. A simple



THE CHIEF COINS OF THE EUROPEAN COUNTRIES

These coins, and their respective countries, are: 1, franc, France; 2, mark, Germany; 3, florin or guelden, Holland; 4, krona, Scandinavia; 5, franc, Belgium; 6, franc, Switzerland; 7 and 11, piastre, Turkey; 8, milreis, Portugal; 9, dollar, United States; 10, leu, Roumania; 12, dinar, Servia; 13, lira, Italy; 14, rouble, Russia; 15, peseta, Spain; 16, krone Austria-Hungary.

calculation will show that this works out at exactly £3 17s. 10½d. per ounce.

Now let us remind ourselves of the actual production of gold in the world in the last fifty years. A plain statement of the facts is given in the accompanying table, and with it is given a statement of the movement of prices as measured by the Board of Trade since 1875—the calculation was not made for an earlier year than 1871.

THE WORLD'S GOLD PRODUCTION AND BRITISH PRICES SINCE 1860.

Year.		Value.	British Prices. Board of Trade Prices Index No. 1900 = 100
		£	
1860	..	28,000,000	Not Calculated.
1865	..	25,000,000	,,
1870	..	27,000,000	,,
1875	..	20,000,000	141
1880	..	22,000,000	130
1885	..	23,000,000	108
1890	..	25,000,000	104
1891	..	27,000,000	107
1892	..	30,000,000	102
1893	..	32,000,000	100
1894	..	37,000,000	94
1895	..	41,000,000	91
1896	..	42,000,00	88
1897	..	48,000,000	90
1898	..	59,000,000	93
1899	..	63,000,000	92
1900	..	52,000,000	100
1901	..	54,000,000	97
1902	..	61,000,000	96
1903	..	67,000,000	97
1904	..	71,000,000	98
1905	..	78,000,000	98
1906	..	83,000,000	100
1907	..	85,000,000	106
1908	..	91,000,000	103
1909	..	93,000,000	104
1910	..	96,000,000	109
1911	..	97,000,000	109

With this table before us, we are able to approach with advantage the relation of the quantity of gold money to prices which are measured in gold. The greater part of the gold produced in the world is actually coined. A certain part is used for artistic and decorative purposes, but it is broadly true that, of the gold shown in the figures in our table, by far the greater part is turned into gold coins by the mints of the world.

Now, we have seen that value is a relative thing. That being so, if more gold is produced, and we measure prices in gold, then prices will rise if the amount of gold produced increases. Equally, if the amount of gold produced falls, then prices must fall. But if more gold is produced, it is obvious that it will buy less of other things which is the same thing as saying that prices rise. If less gold is produced, it becomes comparatively rarer in relation to other things, and therefore more of other things must be given for it, and prices fall. This is a broad statement of what is called the *quantity theory of money*.

Now let us look at the accompanying table in the light of the statements just made. It will be seen that during the period 1860-1890—thirty years—the quantity of gold produced in the world was almost constant, averaging about £25,000,000 worth per annum. During that same period, it will be seen, by reference to the third column, prices considerably fell. The price index number is calculated by the Board of Trade on the variations of the wholesale prices of forty-five principal articles of consumption, and is thoroughly representative.

We at once see that, whatever weight may be attributed to the quantity theory of money, other causes than variation in gold supply must have been at work during the years 1860-1890 to produce the remarkable fall in prices. And this shows us how careful we should be in attributing results to any one particular cause. If the gold production in 1860-1890 had been considerably reduced, we should have been tempted to relate the fall in prices to the quantity theory of money. What really happened in 1860-1890 was this. New countries over the seas were beginning to develop considerably, and, as a consequence, enormous quantities of raw products were put upon the markets, with the result that, through the ordinary operations of supply and demand, prices fell.

Having taken note of this elementary set of facts, and taken warning as to rashly jumping to conclusions in connection with the quantity theory, let us take up the table at the year 1891 and see what has happened since. It will be seen that as from 1891 the quantity of gold produced in the world increased, and continued to do so almost without interruption down to last year (1911), when the gigantic total of £97,000,000 was reached.

Now let us compare the movement of prices in the same period. Down to 1896 prices continued to fall, ***and that although the gold output had nearly doubled in seven years.*** If the quantity theory of money had alone been operative, then prices obviously would have risen, and not fallen, between 1891 and 1896.

In 1897 prices slightly recovered, and they

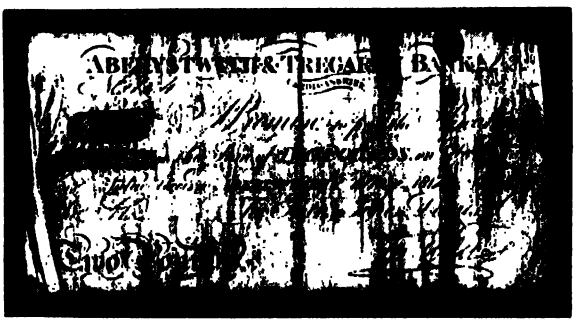
then took an unmistakable upward turn, until, in 1911, the Board of Trade index number was 9 per cent. higher than in 1900 or 1893. A great many publicists have attributed the rise in prices since 1896 as chiefly due to the greater production of gold, but in view of the facts stated in the earlier part of the table it will be seen that this explanation must be received with the greatest caution. If in 1860–1890 we had had a steady output of gold, accompanied by a rapid fall in prices; if in the years 1891-1896 we had a rapidly increasing output of gold, accompanied by a further rapid fall in prices, can we, without the greatest reserve, give weight to the theory that the rise in prices of 1897–1911 was due to an increase in gold production merely because we see that increased gold production and a rise in prices have gone together?

It is probable that the true explanation of at least the greater part of the rise in prices which has occurred since 1896 is one with the explanation of the fall of prices between 1870 and 1896. The world was pouring out food and raw materials, through the opening up of new lands, more rapidly than the increase of the world's population. It was obviously a condition that could not obtain for ever; and after 1896 the production of foods and materials, although increasingly great, did not increase so rapidly as the world's demands. It is thus to the variations of supply and demand of commodities generally rather than to variations in the gold supply that we must look for the chief explanation of one of the most interesting phenomena in the economic history of the world in recent years.

We now pass from money in the form of metallic coins to the fascinating subject of *paper money*. It will be apparent to the reader that the money we have so far considered, the gold currency of different countries, is universally acceptable because the coins obviously consist of a valuable commodity—*i.e.*, they have value as gold, and not merely as tokens of value. A sovereign is a valuable bit of gold. Even if a sovereign be melted, it is still a good and desirable piece of metal; and the same is true of a German ten-mark piece or a French twenty-franc piece. There is no hesitation about accepting gold the world over; and when we offer gold in payment *it is not our credit which matters, but the fact that we offer a known valuable commodity.*

As soon, however, as men began to use money made out of valuable metal, it occurred to trading men that a promise to pay in money written on a piece of paper was as good as money itself, *if the man who wrote the promise was of known credit and probity.* So paper money came to be derived from metal money, and the step was a most important one for the world. It multiplied the use of money, and multiplied money itself, over and over again.

The first banknote was the receipt given by a banker for gold deposited with him. It was a piece of paper acknowledging that so much gold actually existed, held by a respectable firm, and which could be had on demand in exchange for the piece of paper. The banker's note thus became a symbol of gold in existence. It was a tremendous invention, and one which had far-reaching consequences.



A WELSH BANKNOTE OF 1814

The days, however, of the issue of notes by bankers in general have for long passed. In the first half of the nineteenth century the temptation on the part of bankers to issue notes without sufficient security behind them led to many evils, and after a fierce conflict of opinion, and the consideration of the subject by various Parliamentary Committees, the Bank Charter Act became law in 1844. This Act took away from bankers the privilege of issuing notes unless they already possessed the privilege on May 6, 1844; and it further enacted that even the privilege of such bankers was to lapse if at any time they became bankrupt, or ceased to issue notes, or amalgamated their concerns with other bankers. It also gave the Bank of England a monopoly of the issue of notes in London, and for a considerable radius around. As a consequence, the issue of banknotes by country bankers has become almost extinct. As for the Bank of England itself, its note issue is strictly limited in proportion to the gold in the Bank's treasury. Up to £14,000,000, the Bank Act enacted

the Bank of England could issue banknotes against securities worth that sum—£11,000,000 of which was represented by Government Debt—held by the issue departments. Over that sum the Bank of England might only increase the value of banknotes issued if it held gold which it could exchange for them on demand. That is why a Bank of England note is accepted with as much confidence as though golden sovereigns were offered. With regard to the sum of £14,000,000 which could be held in securities, it should be explained that the Bank Act provided that if any country banker ceased to issue notes the Bank of England might add to the issue of its own notes to the extent of two-thirds of the lapsed issue, upon the backing of securities to the same amount.

We may usefully see how the matter stands in 1912.

BANK RETURN

An account pursuant to the Act 7 & 8 Vict., cap. 32, for the week ending on Wednesday, the 6th day of November, 1912

ISSUE DEPARTMENT.

	£		£
Notes Issued ..	53,615,625	Government Debt ..	11,015,100
		Other Securities	7,434,900
		Gold Coin and Bullion ..	35,165,625
	£53,615,625		£53,615,625

It will be seen that the Bank's note issue department held on November 6, 1912, between Government Debt and other securities, the sum of £18,450,000, and in addition £35,165,625 in actual gold, making in all £53,615,625. Against it, under the Bank Act of 1844, they were entitled to issue notes. It will be seen that that amount, £53,615,625 worth, of Bank of England notes were accordingly in circulation. Further, it will be seen that if the holders of these banknotes to the value of over £35,000,000 presented themselves at the Bank of England on a single day they could all be paid in gold, and by the time they were satisfied gold could easily be obtained on the securities in order to meet the whole of the issue. In short, *a Bank of England note is as good as gold.*

But if paper instruments of money were thus confined to promises to pay, backed, like a Bank of England note, by a very large proportion of actual gold held, *instruments of credit would not be of much use.* Happily, civilisation has reached a point at which credit between business men is not so circumscribed. What, in effect, happens at any given moment is that promises to pay gold—*i.e.*, bills of exchange—are commonly passed between persons of credit without any actual demand for gold taking place, except in a small proportion of cases.

Let us be quite clear as to what such paper documents actually amount to. Let us consider the case of three persons—Brown, Jones, and Robinson—exchanging commodities between them. Brown sells £100 worth of goods to Jones. Jones sells £100 worth of goods to Robinson, and Robinson sells £100 worth of goods to Brown. Let us suppose, for the sake of simplicity, that they all bank with the same banker. Brown having sold £100 worth of stuff to Jones, Jones gives to Brown in exchange, not gold, but a piece of paper, a cheque, which is really a bill of exchange payable at sight. Jones having sold £100 worth of stuff to Robinson, Robinson gives to Jones in exchange a cheque for £100, which means a promise to pay one hundred sovereigns. Robinson having sold to Brown £100 worth of stuff, Brown gives a cheque to Robinson. Observe what has happened.

Each has parted with £100 worth of goods, and each has received £100 worth of goods in exchange.

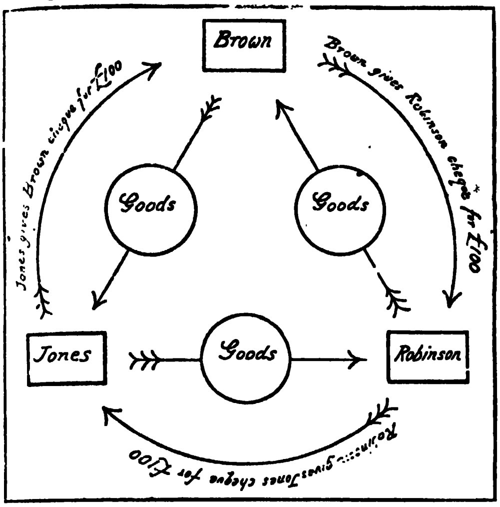
Each has parted with a promise to pay gold, and each has received a promise to pay gold.

All three now pay their cheques into the bank. The bank, by simple bookkeeping, sets off each of the promises against the other, and no gold, or exchange of gold, is wanted at all. The useful purpose has been served of changing goods for goods. Gold was assumed to exist in order to provide a common standard of value by which each measured his bargain. But as a medium of exchange it was not needed, and the paper instruments of credit, the cheques—mere promises to pay gold—took its place.

The diagram on the next page will help the reader to follow what has taken place in this hypothetical instance. It will be seen how, while the goods travelled in one direction, the promises to pay travelled in the other direction, and that, as a consequence, each of the three persons made a useful exchange of goods by using what is really paper money.

Stripped of its innumerable complexities, this is what the process of the use of paper

instruments of credit resolves itself into. Instead of three persons exchanging goods and paying for them in promises, written

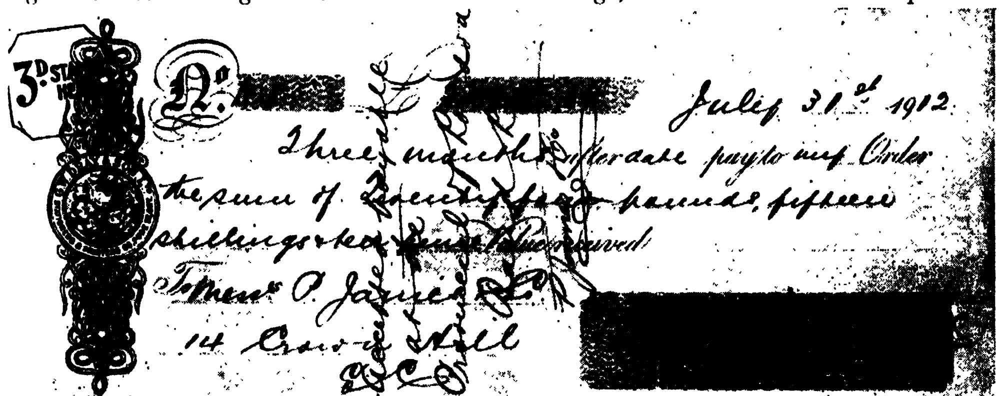


on paper, to pay gold, we have hundreds of thousands of persons exchanging goods and paying for them in promises written on paper to pay gold. Instead of there being one common banker, there are large numbers of bankers. The latter fact presents no difficulty, for, of course, the bankers club together to set up a central Clearing House, to which they transmit all their paper promises to pay, in order that they may be set off against each other, just as in the simple case we have imagined one single bank sets off against each other the promises to pay gold written on bits of paper by Brown, Jones, and Robinson.

Now the reader will more clearly understand why we stated earlier in this chapter that gold money, in every instance of trade in this or any other gold-standard country, is used as a *standard of value,* but that as a *means or instrument of exchange* it is rarely used save in small-scale transactions. Promises to pay gold are used which never need be carried out, because people do not want gold; what is wanted is wealth or commodities in a thousand different shapes, and these commodities are valued in gold.

The entire process is singularly effective, and it marks in the development of mankind a high degree of civilisation and widespread integrity. In trade we are happily able to assume that the normal man of business is a man whose promise to pay is good up to a certain point corresponding to the scale upon which he trades. Each business house rates its customers by their standing and by experience. Failures occur, of course, and dishonoured paper instruments of credit not uncommonly occur. Nevertheless, the instances of failure are the exceptions which prove the general rule of credit efficiency.

It will be seen that we have very widely to enlarge our conception of what constitutes "money." At any given moment the money of the United Kingdom consists not only of the gold coins which are legal currency, and the banknotes which can be exchanged at any moment for gold lying at the Bank of England, and the comparatively small amount of silver and copper token money which is only legal tender for very small sums, but of the enormous mass of credits which are afloat, and which, in whatever form they are made, whether as cheques or bills of exchange, resolve themselves into promises



A BILL OF EXCHANGE

to pay gold either at sight, as in the case of a cheque, or at some future date, as in the case of a bill of exchange.

Paper instruments of money are in effect coined goods. Let us give a simple illustration of this. Let us suppose that a man possesses a freehold house worth

£9000. We mean by that that its exchange value in terms of gold is that it will exchange for nine thousand sovereigns. Let us suppose that the freeholder desires to have the free use in other ways of part of the value of his freehold house. He can go to his bank, or to some other moneylender, and mortgage his house—*i.e.*, raise on the credit of his house up to about two-thirds of its value—*i.e.*, up to £6000. His bank, in return for his signing a proper instrument which assigns the house as security for the loan, places at his disposal £6000, which he can immediately draw in gold if he wants it, but which in practice he does not draw in gold at all, but has put to the credit of his banking account, so that he can draw upon it as he wants it. Let us think what has really happened. It will be seen that, in effect, two-thirds of a certain material thing, a freehold house, has been coined into money. It has not been turned into gold. It has simply been turned into a promise to pay gold, and that promise is just as useful as gold itself for the reasons we have already explained.

So it is with other things. On the general credit of his business and stock a business man can go to his banker and obtain an overdraft—*i.e.*, a loan of money, for which he pays a certain interest. The business man does not draw gold for the overdraft ; he draws cheques, which enable him to get the commodities he wants. What has really happened is, as in the case of the mortgage on the freehold house, that part of his business has been coined into a currency which is not legal tender, but rests on the known value of his business.

Let the reader endeavour to bethink him what an enormous mass of such credit money is in circulation at any given moment. We say " endeavour," because the amounts are so stupendous that, while we can easily write them down on paper, the mind cannot grasp their true magnitude. Let us look at the actual figures.

Paper money—i.e., cheques and bills of exchange—cleared at the London Bankers' Clearing House

1900	£8,960,000,000
1901	9,561,000,000
1902	10,029,000,000
1903	10,120,000,000
1904	10,564,000,000
1905	12,288,000,000
1906	12,711,000,000
1907	12,730,000,000
1908	12,120,000,000
1909	13,525,000,000
1910	14,659,000,000

The above are the amounts cleared at the London Bankers' Clearing House in 1909-1910.

The clearances are now at the rate of over 15,000 millions a year, which is about £50,000,000 for each working day in the year. In addition, of course, there are considerable clearances of country cheques in the provinces. Add to this the consideration that there is an enormous number at any given moment of overdrafts or loans by bankers to their customers. Add to this the fact that an enormous number of freehold and leasehold properties are mortgaged, the mortgages being usually redeemable only upon six months' notice. These things being so, let us think what would happen if all the people possessing paper promises to pay gold in a single week went to their banks and demanded gold in exchange for them. There would not be enough gold in the country to meet the demand, and every bank, including the Bank of England, would have to shut its doors.

Of course, such wholesale folly is not likely to occur, but we are reminded by the facts we have considered of the curiously small basis of actual gold—there is probably not more than about £150 million worth of gold in the country—upon which is erected an enormous pile of promises to pay gold. The position has been compared to a pyramid resting upon its apex, but is that a just symbol ? Surely the broad truth is that the enormous pile of credit instruments does not really rest upon the small amount of gold, but rests upon the wide basis formed by the great mass of accumulated wealth of the country.

When we lend money upon the security of a house, we do not worry about gold; all we need trouble about is that the house is a valuable commodity. It is true that it is valued in terms of gold, but it is the masonry, the bricks and mortar, the building, and the land upon which it rests which properly bulk in our mind as the thing which is the basis of the credit involved. Similarly, when a banker gives an overdraft to a customer, what he looks at is not the absurd conception that this customer to whom he lends possesses a large number of gold coins, but that he has a valuable stock-in-trade and a business yielding certain regular profits. These form the solid basis which are the foundation of the banker's faith when he allows an overdraft.

Thus, also, when we part with goods and receive in payment a bill of exchange—*i.e.* a bit of paper upon which we write a demand to the person to whom we sell the goods to pay us gold at some future date

and across which he writes "Accepted." Our faith in the paper instrument does not rest upon the possession of gold by the person accepting the bill of exchange; it rests upon the fact that he is a man who can furnish goods to us, or to other persons, so that we can either get goods from him in exchange for our goods, or goods from third parties who owe him value in exchange.

The Possibility of the Whole Credit System Tumbling to Pieces

While these things are absolutely true, however, the fact remains that each bit of paper money is in the last resort a promise to pay gold, and we must not, therefore, dismiss from our minds as a practical consideration the fact that, if there came a great shock to public confidence, the entire credit system might tumble to pieces. If, through the imminence or actual occasion of war, a large number of timid investors rushed to their banks and demanded gold for what was due to them, nothing could prevent under the given circumstances the collapse of credit, because the bankers' stock of gold is so small that it would give out, and in a short time gold would have to be refused.

Only the public ignorance as to what money really is could start such an insane demand for the gold which does not exist, but it is unfortunately the fact that, although we pride ourselves upon being an educated people, a very large part of the public is not acquainted with the real facts of the case, or with the real nature of money and credit. There is little doubt that many people who possess bank balances are ignorant enough to believe that "money" in the sense of gold exists in the country to pay out all the bank deposits in the country. Moreover, even those not so ignorant as that might start a panic in rushing to make themselves secure by being amongst the first to realise their deposits out of what little gold there is.

What Minimum Amount of Gold Should be Kept to Meet Panics?

This brings us to the consideration of what ought to be the minimum of gold which, in view of all these circumstances, banks ought to keep in order to meet any panic demands that may be made upon them. Upon this question there has been unlimited discussion and unlimited difference of opinion in banking circles for a long time past. The question has been raised in Parliament again and again, and many Chancellors of the Exchequer have promised to give it their "very earnest and serious consideration at the earliest possible moment." As things are, we have no law compelling a bank to limit its liabilities to depositors in ratio to their gold reserves; there is nothing to prevent one of the great banking corporations from trading with an almost negligible cash reserve. The confidence in the integrity and efficiency of our bankers is so great, however, that we carry on very well and very smoothly in spite of the absence of legal enactments. Nor must we too readily suppose that a mere legal enactment that banks must keep, say, 30 or 35 or 50 per cent. of cash reserve against the possibilities of having to pay gold on demand would be a complete safeguard. In America they have such a law, the national banks being compelled to maintain cash reserves equivalent to 25 per cent. of the deposits made with them. Does that protect banks in America from "runs"? Not at all. As recently as 1907 we saw a serious financial panic in the United States, in which the rush on the banks for gold was so tremendous that the banks had to stop payment.

Education in the Folly of Panics the Only Real Safeguard

In fact, as will readily be seen, it is practically impossible to provide against possible panic folly beyond a certain point. If we attempted to limit the operations of banks to the small compass which would be defined by the keeping of amounts of gold always ready to be paid on demand, business would be seriously contracted, and we should all be very much poorer. It may well be that it would be an improvement to enact that the banks should keep on deposit at the Bank of England larger gold deposits than is now actually the case, in order to maintain them in a position to fend against the worst sorts of possible financial panic. It is practically impossible to do more than that.

One of the best safeguards against an insensate rush for gold in time of stress is the better education of the people, combined with State oversight of all institutions concerned with credit. The public should know that any institution trading as a "bank" is subject to Government audit, and that its solvency is therefore maintained. No boy or girl ought to leave school without understanding the money system. Now it is not thought necessary for a moment to teach the quite elementary matters with which we have dealt in this chapter, though, as we have shown, they are by no means recondite or difficult to understand.

THE GAMBLING MANIA—CHANCE VERSUS INDUSTRY: A COMPLETE NEGATION OF ALL THRIFT

THIS PICTURE OF A COLLEGE CARD-PARTY, BY W. P. FRITH, R.A., FORMS ONE OF HIS "ROAD TO RUIN" SERIES OF PAINTINGS

SOCIAL ASPECTS OF THRIFT

The Institutions Through Whose Operations Men Seek to Save, and So Secure a Sounder Independence

SAVING AS A DUTY AND AS A MISTAKE

A DISCUSSION of the relations between Society and the practice of thrift, or saving, may proceed naturally along either of two lines—that of political economy, or that of individual advantage with aspects more distinctively and narrowly social. It is the latter line, with its immediate and practical bearings, that we are about to follow, resisting the temptation to discuss what rather belongs to the section on Commerce—namely, the place of saving in the finance of trade.

Incidentally, it may be remarked that shrewd critics of the old economy of Adam Smith and John Stuart Mill have felt delight in pointing out the paradoxical position that would be arrived at if all the good advice about avoiding expense were to be followed, and if everybody tried to save in a spirit of parsimony. Everybody would then be accumulating money, in the hope of setting more labour in motion, and producing more commodities, which, again, everybody in his penuriousness would avoid buying. Evidently it is necessary, on the economic side, that any general theory of saving should be accompanied by an ideal of wise spending and intelligent consumption. Saving, on its own account, is no virtue; its merit depends upon the uses to which the savings are put, and how far, in the end, they minister ultimately to a finer and fuller life.

Further, any argument on the broader economic aspects of thrift would lead almost inevitably to a discussion of the bases of wealth, as they are contested in politics whenever legislation that is called Socialistic is to the fore. Ought the State collectively to accumulate capital in wise proportions, use it in wise productiveness, and regulate individual consumption so that all should have enough, while none lacked, and so leave no one any reason for saving? That is the kind of question to which economic theory tends, and which we mention only to avoid. The state of things suggested in such questions is not here, though the community, as a preserver, has taken some firm steps along new paths, in Old Age Pensions, the Insurance Act, and medical treatment of the poor and the young. But the miseries that spring from waste and extravagance are here; and the remedies, to a very large extent, for the time being, are individual rather than public and general. Saving and personal initiative have to be relied on, with but slender help, if any, from theories of universal economy; and so we turn to the individual and domestic view of thrift.

Saving is a cultivated, not a natural impulse. The lowest savages do not save. They revel and waste, and then suffer want. Saving only comes with reflection, and considerable advance in civilisation. To see how much thought and training are needed to enable men to save aright, and spend aright, we only need look around, or perhaps within. Quite obviously, in such a country as England, there is abundance of wealth, or the means for producing wealth, if men and women only showed good sense in saving and spending. True thrift, which embraces both saving and spending, would diffuse a modest but substantial prosperity almost everywhere.

The number of people who are in uncomfortable circumstances either because of extravagance or muddle, which spring from the absence of any economic organisation of their lives, must be immense. See the men walking the main streets of any town about half-past seven in the evening, and ask whether what they are doing, or about to do, is either necessary or beautiful, or intrinsically worth the money it will cost. The answer is "No." What is done is customary but uneconomical. They might much better keep the cost of it in their

pockets, as they would do if they lived in a different place, under different circumstances, seeking good fortune. For example, most of those who pass us are probably going where they will drink what they do not need, smoke what will do them harm rather than good, and will watch some amusement that is stalely well known, and not spontaneously enjoyable. For all this something will be paid that might be sent through other channels—the mediums of thrift—to produce the means of far more solid satisfactions in later years. If these people were in, say, Canada, they would certainly not be drinking, possibly not smoking, probably not paying for amusement, and they would be saving up money as fast as they might have saved it at home with more self-restraint from useless spending. But the spontaneous impulse is towards the immediate gratification of spending.

The Honeycombing of Society by Debt and Financial Insecurity

What is the effect of this unthriftiness? A single purgatorial word gives the result—debt. Doubtless there are people who can live in debt and be happy, during intervals of forgetfulness, but that is because they have never realised the splendid freedom of independence. Upon the heels of debt follow dependence, in one or other of its forms, a falling away from manliness, and temptations that would not occur to any one who felt that he was at no man's mercy financially. The social effects of unthriftiness honeycomb society like a worm in the wood, and some popular forms of trade seem to be designed to keep those who submit to them in a state of dependence.

This is true of almost the whole credit system as it is practised in retail business, and to a considerable extent in the wholesale trades. The aim of many credit firms is to bind their customers to them by debt that is safeguarded by stringent restrictions, and then to act towards them, in effect, not only as tradesmen but as moneylenders.

The Unthriftiness of All Forms of Delayed Payment with Interest Charged

That this is so must appear to anyone who thinks steadily for five minutes about the organisation of his income, what he can get for it in cash, and what he must pay out of it if he buys on credit under an extended system of after-payment. He is buying the nominal ownership of a share in the article he desires, and is paying a heavy interest for the loan of the remaining value, tempted by an appearance of immediate possession. Anything more unthrifty for the purchaser could not well be devised. From the point of view of the trader it makes usury respectable by linking it with industry.

Comparatively few middle-class people are aware how widespread is the thriftless credit system in association with direct moneylending, and how, as the very beginning of saving, it is necessary to learn the lesson of buying only what can be paid for, and paying only in cash. For instance, a working-class family in the courts of a manufacturing city reach the point when it is necessary to spend, say, a sovereign on the better dressing of some of their children. Perhaps there is a public appearance at the school, and the children will have some prominence. The wages of the father are twenty-three or twenty-four shillings a week, rent is high, and drink is an occasional temptation to father, and perhaps mother. There is no money available for the clothes, and the family has no credit with tradesmen who supply clothes. The popular way out of this difficulty is viâ the peripatetic moneylender. He is calling on Monday in the court to gather up the payments of his customers; and what so easy as to call him in and borrow the necessary sovereign that seems to ease all immediate difficulties?

How the Poorest Borrow Money at Enormous Rates of Usury

What are the terms? For the sovereign, twenty-three shillings must be paid back by weekly payments of a shilling; or, if a single payment is omitted, twenty-five shillings must be repaid. The lender pays himself the first week's shilling at once, so that the borrower only gets nineteen shillings. Then he asks in friendly concern what the money is wanted for, and learns it is for clothes; whereupon he mentions that at a shop he can name he has influence in getting new clothes, and indeed will give them an order, or, if they like, he will pay the nineteen shillings himself. And so the purchaser of nineteen shillings' worth of children's clothes pays twenty-three, or, perhaps, twenty-five shillings, and also, though he does not know it, a commission from the tradesman to the moneylender for procuring the custom and financing the customer. In this way the poor family has been borrowing money at the rate of from 40 to 60 per cent. per annum, because they had not the foresight to save the money before spending it.

Who can wonder that poverty clings to the people along certain social layers when these methods of managing income abound?

Indeed, the case we have presented is a favourable one, for the children would get the clothes; while, in many cases, such borrowings at high interest are arranged to find money for betting that ends in total loss. The most splendid tribute given to the inherent honesty of the British people, even when they are overwhelmingly foolish in their handling of money, is found in the fact that these weekly repayments of money borrowed are kept up with remarkable fidelity.

The Period in Many Lives when it is Wrong to Save

The ramifications of the credit system could be followed through all grades of society, showing that there is no need to go to India or Ireland for a people in chains to usury, and that the first step towards thrift is to keep out of the hands of those who sell money.

But is there not a line, it may be asked, below which the saving of money is impossible, and talking of it is a mockery? Undoubtedly that is so at certain periods of many working-class careers, though the spirit that would save is then least of all open to criticism. While it may be true that, when the family is large and young, all the energies of father and mother may be exerted in a strained attempt to provide the plainest necessaries of life for the home and brood, and saving is impossible, those who have the spirit of providence well developed, and who will save when they can save, are just the people who will weather safely the turbulent passage in life when children are many and hungry and sad little clothes-wearers. They will not become reckless, and give up the struggle. The only danger is that they may not face the fact that, under certain conditions, saving must cease for the children's sake.

The Immediate Wants that are More Important Than Any Requirements of the Future

Where must the line be drawn against saving? It is quite clear that in the cases of a man who must spend his strength on stern manual labour, or a woman who needs all her vitality for motherhood, or children who are being given either a good or a bad physical start in life, no prospective comfort, through saving, can outweigh the immediate demand for sufficient sustenance. The family must be fed, clothed, housed, and warmed up to a satisfactory standard—that is, the standard necessary for physical efficiency—otherwise injury by pinching becomes just as bad as injury by waste and want. At what point the line of necessity is drawn, marking where saving may possibly begin, depends almost wholly upon the skill and knowledge of the wife. That a man must ask his wife if he can live is as true of the poorer as of the larger wage-earners, and perhaps more true. There is, however, always a danger that the extremely thrifty, in their revulsion from poverty and dependence, and their eager habit of accumulation, may forget that immediate plenty is the first imperative demand, and grasping at future welfare at the expense of present necessities may be grasping at a shadow, or, even if successful, preparing the mind for that least human of failings, the misery of the miserly.

What are the devices that present themselves most readily to the wage-earning and lower-middle class as methods of saving? Few will realise how recent is the public organisation of saving available for all, however slender their resources. It is only within call of these modern days that poor men could be sure of safe ways of saving, except by hoarding. The old wife's stocking-foot, represented today, as a method of training, by the child's money-box, was the original plan. People hoarded and concealed their spare money.

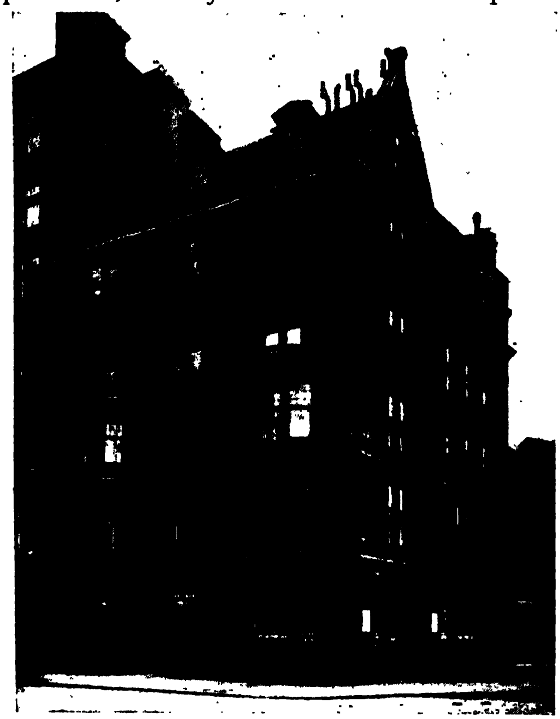
A Man who Inspired Men of All Nations with a Desire to Save

Probably the greatest personal influence ever exercised in the world in favour of carefulness, the accumulation of a reserve against poverty and as an assistance to business enterprise, was Benjamin Franklin—a journalist, statesman, and philosopher whose all-round character has not even yet been given its right position in the world's story. The one little book that everyone wanted, as the world broadened out, was an almanack, and Franklin studded his almanack with the maxims of thrift gathered from the popular sayings of all peoples, and pointed by his own shrewd sense and wit. Sent out from a Pennsylvanian printing-office, Franklin's sayings by *Poor Richard* reached every nation in its own language, and stimulated a desire to save throughout all the millions of the white races. It was a simple influence, but enormously powerful, because it operated individually everywhere.

Organised methods of saving, by the use of banks, we must remember, are of comparatively recent origin. The Bank of England itself was only incorporated at the end of the seventeeth century, about the time when Defoe was suggesting trustee savings banks; but it was not till a hundred years later, in

1799, that the first English savings bank was started; and the Post Office Savings Bank system was not authorised till 1861. Now there is probably no one so ignorant as to be unaware of the use of a bank, and forms of supposed saving are thrust under the notice of the poorest. Children are taught to take a pride in their little banking account, kept, perhaps, for a temporary purpose, but often made the nucleus of life-long savings. Though the need for thrift may not seem so clear as it was, there is no lack of methods.

Before looking at some of the plans by which thrift is now promoted, it may be well to ask whether the recent action of the State in compelling insurance and providing Old Age Pensions will tend to destroy the incentives to diligence and a wise frugality which were strong before the State began to play the part of foster-parent to all ages. It may be said that, when all are provided with insurance grants in case of sickness or unemployment, and with an annuity in old age, the chief reasons for present carefulness, in order that future necessities may be provided for, will have disappeared. But does not the desire for accumulation arise largely from self-respect, and show weakest in the hopelessly poor? And will not the State aid preserve that self-respect, and so strengthen the wish to make at least such supplementary savings as will retain comfort to the end of life? No State aid ever proposed is sufficient to satisfy the wants of any man with a spark of ambition. The man who has something wishes for more; it is the man with nothing who is hopelessly lethargic. State aid, we suggest, will have, in the long run, a stimulating rather than a benumbing effect, and will be an ally and not a neutraliser of thrift.



THE NATIONAL PENNY BANK, LONDON, ONE OF THE OLDEST THRIFT INSTITUTIONS

The commonest popular forms of saving have been and are, by clubs and friendly societies, trade societies, insurance, co-operation, building societies, and the savings banks—a wide range compared with the paucity of methods a century ago. Each of these devices calls for brief comment.

To anyone who knows the general story of the "club" movement, as illustrated in local working-class combinations, the word is one of evil omen. Only gradually was the actuarial position of clubs understood. The usual aim was to secure, co-operatively, inexpensive medical attendance, and some "club pay" in times of sickness. Often the scale of payment was inadequate for provision of the promised benefits, or the management was unbusiness-like, or the funds passed into untrustworthy hands with the result that when men were too old to join another club, the hope of their advancing years proved pathetically delusive. Clubs that were constantly fed with young members have, however, often lasted long; and the great friendly societies, as distinguished from the more local and sectional combinations, have been carefully making their financial position sounder, until they form, in the aggregate, a most substantial and impressive illustration of thrifty efforts to meet some of life's more serious contingencies.

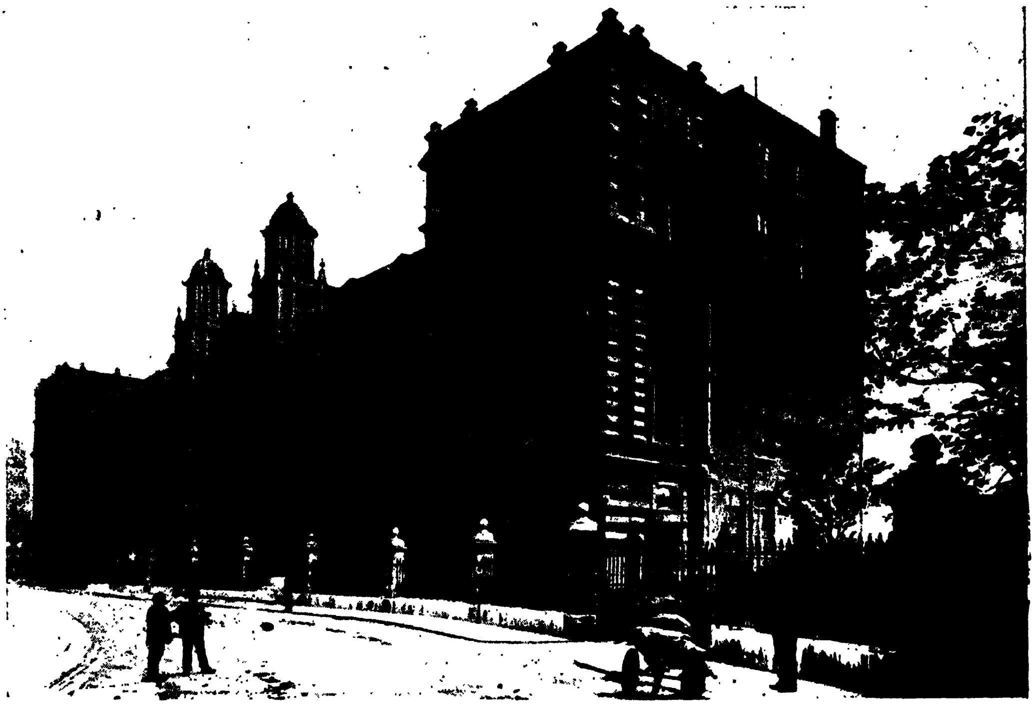
The various trade societies, the unions of workmen engaged in the same craft, have usually had subscriptions more commensurate with the advantages ultimately accruing, often, in the case of the better-paid skilled trades, including a superannuation allowance. It is strange now to note how long the bias against these societies persisted. Even Dr. Smiles, the lioniser of all who "get on" by industry and thoughtful economy, inveighs, in one of his books, against men who spend part of their earnings on their trade union, when they might be saving the money individually. If th

author of "Self Help" had known more about the unions he slighted, he would have been aware that in many cases they have been outstanding examples of co-operation in thrifty provision for declining years.

How far insurance—apart from the State scheme recently brought into operation by the legislature—is, on the whole, a genuine adjunct of thrift is a question open to interesting debate. In some form or other, an enormously large proportion of the families of our country pay insurance money, either for the children or for the breadwinner. The strong arguments for insurance as a form of thrift are two. First, whether the amount saved by this process is adequate in proportion to the outlay or not, in many cases if it were not saved in this way it would not be saved at all. The mother will pay to a collector weekly pence that would otherwise be spent without leaving any trace of advantage.

Then, too, the insurance covers risks which it is a man's duty to cover, even if it involves some financial sacrifice. Seeing that life risks are covered, it is perhaps unfair to press the point that insurance, considered strictly as an investment, is, on the whole, uneconomical. It must be so, seeing that insurance offices have large expenses of collection and administration, and divide considerable profits among shareholders, while their investments ought not to earn high rates of interest. These demands cannot leave an ordinary investor's profit for the outlay of the insured person. Still, it is much to have covered risks, and to have saved what one has paid, even if the surplus is less than it would have been through a perfectly secure ordinary investment. Insurance is more than a safeguard against some of the effects of death; it is a safeguard against slackness and indecision in saving.

Many of the working classes use the co-operative trading movement not only for the purchase of household supplies on what they regard as preferential terms, but as a medium for saving and investment. The co-operative store is really their bank. To it they lend such money as they can spare from current expenses, and so it becomes very distinctly an adjunct to thrift, especially as it pays a substantial rate of interest. The store, too, is probably easily accessible and familiar, and the investor is stimulated amidst such surroundings by the pride of saving, so that co-operation may offer useful chances of thrift to a beginner.



THE HEADQUARTERS OF THE POST OFFICE SAVINGS BANK, WEST KENSINGTON

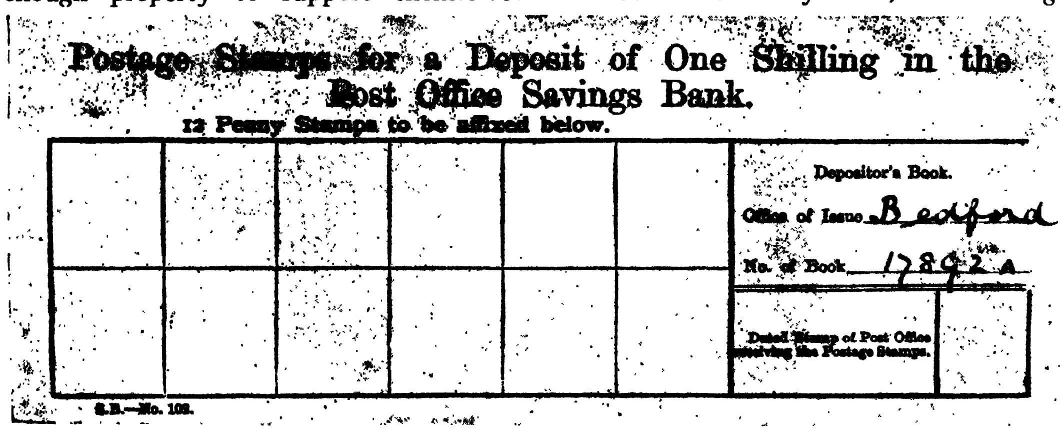
In many parts of the country, where the

population is of a settled character, with no desire to roam, the building society has been a most convenient institution for enabling men to utilise their savings. Here, again, sound methods of procedure have been slowly evolved out of painful experience. A study of the various Acts of Parliament prohibiting what may not be done by building societies, and defining what may be done and what must be done, is full of suggestive information. Indeed, the whole question is so bestrewn with pitfalls that it is difficult to steer a course between just praise of a useful method of saving and necessary warnings against unsafe conditions of investment. Tens of thousands of men, by the operations of sound building societies, have transformed their savings into land and houses, and, living rent-free themselves, have acquired enough property to support themselves modestly in old age, whereas if they had risked their money in business speculations the chances are they would have lost some, or all of it. Under favourable circumstances, praise of the building society system is loud in the land of the thrifty.

But there are manifest disadvantages attending building houses as a method of saving, unless the conditions are favourable. The society must be managed by honest men, with business ability and knowledge of the value of property, and must be kept to its purpose of co-operatively advancing money to build houses. The place where the houses are built must be well chosen, so that they will be certain to let readily, and not degenerate rapidly into haunts of a less desirable tenantry. In building a house for oneself—a great saving on paying rent—it is necessary to be assured firmly of fixity of residence, for the absentee property-owner is bound to be a loser, and savings tied up in house property can rarely be liberated except at a disadvantage. Then, too, the presently prosperous, thrifty man who builds for himself is liable to underrate curiously his ultimate requirements. Perhaps as much money has been lost on house building as has been saved on it. Yet it remains a useful method of thrift for those who can make sure of the continuance of favourable surrounding circumstances.

The most useful of all institutions, however, for the thrifty is the Post Office Savings Bank. In many respects its features call for unreserved admiration. It is located everywhere ; it takes the smallest sums ; it commands complete confidence ; it readily releases, as well as accepts, savings committed to it. It is true that the interest it allows is extremely small, but that might be forgiven if in other respects it acted up to its general repute. Why the savings of a year should be limited to £50 ; why the total amount of money to be saved through the Post Office should be £500 ; why the limit of an annuity purchased through the Post Office should be £100, are tantalising puzzles. If this business is a necessity of national range, surely it is worth extending beyond these excessively modest limits.

Any change should be in the direction of expansion. Seeing that the State takes in hand the insurance of the poorest as a pressing duty, surely it can spare some guidance and additional security for the great numbers who have passed beyond the bounds of poverty and yet are in doubt as to how they shall preserve the fruits of their thrift. Society will yet recognise its duty to the anxious but incompetent investor.


Postage Stamps for a Deposit of One Shilling in the Post Office Savings Bank.
12 Penny Stamps to be affixed below.
Depositor's Book.
Office of Issue Bedford
No. of Book 17892 A
Dated Stamp of Post Office receiving the Postage Stamps.
S.B.—No. 102.

THE SIMPLEST OF ALL METHODS OF SAVING

THE WORST RACIAL POISON

The Effects of Alcohol Passed on from Generation to Generation as a Transmitted Degeneracy

THE DRINKING HABITS OF MOTHERS

We pass now to the last and most important of the racial poisons, ethyl alcohol. Its action upon the individual body has been discussed in another section of this work. That action, in many instances, is so marked that we might well expect the drug to influence the germ-plasm as well as the somatic, or bodily, tissues. But this cannot be assumed, for we know many agents which injure the body in greater or less degree and do not appear to harm the germ-plasm at all. The action of alcohol on the germ-plasm requires very exact and various forms of scientific inquiry, under conditions which exclude the many possible fallacies of careless estimation; and we shall see that a large number of observers, in various parts of the world, have devoted themselves to this subject, and have found the facts. They have until very lately been opposed by one or two authors, who have made no first-hand study of the subject, and have been misled by the popular perversion of Darwinism, that "acquired characters are not inherited." In a matter of such importance and such scientific interest we shall require to state the evidence in some detail.

We defined alcohol as the most important of the racial poisons, and the adjective requires definition. The parasitic poisons which were discussed in the last chapter are vastly more virulent. In many cases they put an end to the possibility of parenthood at all; they actually kill the germ-plasm outright, as alcohol can do only after some years of excess. Short of that, these parasitic poisons may produce extreme and outrageous effects upon almost every part of the offspring, not merely being content with a general lowering of vitality (especially of nervous vitality), but even rotting the very bones and joints. If the action of these racial poisons were as widespread as that of alcohol, the race would long ago have disappeared, and there would be none left to tell the tale. But their action is numerically restricted, and is becoming ever more so. Where their incidence falls, it is terribly, often fatally, destructive to the race, but it falls upon only a very small percentage of the community; and modern methods of prevention and treatment promise us the early extirpation of these diseases, when public opinion permits.

The action of alcohol much more nearly resembles that of lead. In both cases, the poison cannot, so to say, *generate itself*. If such and such a quantity enters the body of the parent, and passes into the germ-plasm, or if it passes into the offspring when the expectant mother receives a dose of it, we have to reckon, at any rate, only with the quantity in question. But when living parasites are passed into the offspring, we have to deal with a poison which, so to say, multiplies itself indefinitely. The case of lead and alcohol is obviously different. Here we have to deal with a finite intoxication only, not with an infection which breeds and leads to indefinitely extended intoxication.

Whether lead or alcohol is the more serious as a racial poison, in the cases where they occur, we need not trouble to decide. Perhaps lead is more certain, in any given instance, to produce effects upon the offspring which are unmistakable and gross. But the all-important fact is that, while plumbism is rare, alcoholism is common. No one argues that teetotalism from lead is a silly fad, and that "true temperance" is to take it only between meals; and, lastly, the poison does not induce a habit. Sociologically considered, no one lives by the consumption of lead, but millions of people live—though millions more die—by the consumption of alcohol. Thus, though

the two poisons may be coupled and paralleled in the mind of the scientific student, for practical purposes there is no serious comparison between them.

Yet one other fact, bearing upon the unique importance of alcohol as a racial poison. In the case of lead we saw that the poison is more potent when it acts through the mother than when it acts through the father. We have abundant clinical evidence of this fact in our own species, and it has been demonstrated in the lower animals. The same fact of the much more serious influence of maternal than of paternal poisoning can be shown for the case of alcohol, both in our own and in subhuman species. The reader will observe that the poison can act upon and through the germ-plasm itself in both sexes alike; but in the case of the mother it can also act by means of the ante-natal nutrition of the offspring, and later still. Hence it is only when the mother has ingested the poison that we can find it actually present in the tissues of the offspring after birth. In exact parallel with the ante-natal nurture, there is the post-natal nurture of the offspring by means of the mother's milk, which may contain either lead or alcohol if the poison is entering the mother's body.

The Evil Omen of Increasing Alcoholic Drinking by Mothers

The importance of alcohol as a racial poison, therefore, lies in the fact that the young mothers in this country, especially in the industrial North, and in those classes from which the birth-rate chiefly comes, are drinking as they never did before. This is the *one* ominous fact of alcohol in this country. The others are favourable. We are not cursed with absinthe, as France is, and as Switzerland was until, thanks mainly to Professor Forel, a referendum was taken, and the poisonous liquor was banned altogether on Swiss soil. The absinthe manufacturers began to consider the possibility of finding a new market in England, but we were able to turn them off. We are drinking far less alcohol than we used to do, and in less deleterious forms, on the whole. The convictions for drunkenness are not a safe criterion, but we may judge by the precise figures of the national drink bill, as communicated annually to the "Times" for many years by the late Dr. Dawson Burns, and continued since his death. The consumption of alcohol per head steadily and markedly falls, on the whole, from year to year, and has been doing so for a long time.

The one fact of evil omen is that, according to all the evidence that can be cited, this fall is due to the altering habits of the male population, who drink much less than they did, while in certain sections of the female population there is far more drinking than ever before. Now, from the racial point of view, it is certain that this alteration in the sex-incidence of alcohol consumption is to be deplored. Nature has made the mothers of a race more important than the fathers. In pure heredity the sexes are absolutely equal; so far as the germ-plasm is concerned, we have no reason to suppose that alcohol does more or less harm in either sex.

The Comparative Unimportance of Alcohol to Those who will not be Parents

But the mothers have such intimate and prolonged relations to the nutrition of the next generation, ante-natal always, and post-natal most desirably—for nothing can quite replace the maternal breast—that any poison which acts through them can act for months, often for a year and a half, upon the developing tissues and organs of their children.

From the eugenic point of view, and considering the definite evidence before us, it is clear that, if a nation is to consume a given quantity of alcohol, those who will never thereafter be parents are the most suitable persons to do so, those who will be fathers are the next, and those who will be and are being mothers of the race are the last whom we desire to share in the communal consumption of the drug. Where the race is in any case going to come to an end, since the individual is not going to contribute to it, then the action of a racial poison matters nothing as such. It is the parents and the possible parents that matter.

The Vitiation of Statistics of Sobriety if Women Drink

Unfortunately, very few of us have yet acquired the habit, which has become second nature with the Eugenist, of looking at the existing generation in terms of those that are to come. When we do so, we realise that individuals ought to be thought of as belonging to two totally contrasted classes—those whose life will pass with themselves, and those the life of whom will be prolonged in the race. Once this distinction of destiny is seen, we begin to wish that all our national statistics could be restated in terms of the incidence of any factor upon the two sections of the community—those in whom the stream of life will stop dead, and those through

whom it will run on towards the destiny of mankind.

Of these latter, as we have seen, the mothers matter more than the fathers. Hence, when we learn that the consumption of alcohol per head of population was covered, in 1910, by a sum of £3 8s. 11d., as compared with £4 12s. in 1900, a fall of 25 per cent. in ten years—while we congratulate ourselves—we require also to remember that, from the eugenic point of view, people vary in their importance, and that the facts may be far less promising if they cover the change, that clubmen, athletes, and commercial travellers are drinking less and the young women more.

The Liability to Make False Charges of Hereditary Conditions Against Drink

We proceed, then, to define the action of alcoholism upon the offspring, and, in the first place, to define a fallacy which has long done ill service in this connection. It is simply stated. We observe the children of the drunkard and find, perhaps, that they are defective-minded. At once we say, "Behold the consequences of the parental alcoholism!" But it may be that the parent was also defective-minded, with that lack of self-control and that susceptibility to alcohol which mark such people. Hence the parent became alcoholic. The alcoholism is here a symptom, an effect, of the disease, which was an inborn defect of the parent, and, as such, was liable to be transmitted to the offspring. The parent might have been cared for in a colony from infancy until adult life, and then have become a parent with a complete teetotal history. The offspring would have inherited whatever was inborn in the parent, according to the laws of genetics, all the same.

Hereditary Evils Transmitted Through Drink Immediately and Ultimately

Here, then, is a tremendous fallacy, which we have been far too late in recognising. It was first pointed out by Dr. Caleb Williams in his book "The Criminal Responsibility of the Insane," published in 1856. But for decades after that date writers on the subject, not realising the importance of heredity, were content to assume that all defects in the offspring of drunkards were due to the drink, though the proper kind of inquiry would have shown that in many cases the defects were inherited from the parents, and the alcoholism was merely an associated symptom. Our knowledge, however, is now such that we can identify these; while we need not be so foolish as to suppose that they make impossible the existence of other cases where the alcohol originates defects in healthy stocks.

The results of criticism of the evidence adduced until the most recent years show that alcoholism has not been immediately responsible for a very great part of the marked nervous disease, insanity, and feeble-mindedness which have been put down to it. We have, however, introduced the qualifying adverb "immediately"; for there is much reason to believe that the continuance of alcoholism, from generation to generation, may account for the origin of these defects in the first place, and they would then be transmitted, independently of the subsequent occurrence of alcoholism among the individuals who exhibited them.

When the problem is thus better understood, we begin to feel that the only short and definite way of ascertaining what alcohol does will be to observe its action upon the lower animals, where the successive generations follow one another quickly, and where we can be sure of the individual health and of the ancestral health of the individuals whose progeny we observe. Such experiments have been made by a large number of observers in this country, on the Continent, and in America.

Experiments on Animals of the Racial Effects of Alcoholism

No observer of all these has failed to find degeneration of the offspring following upon parental alcoholism. The fact is worth noting, for there have been wide variations in the details. Various species of animals, including dogs, rabbits, and guinea-pigs, have been employed, and there have been many years in which the few writers who deny the action of alcohol as a racial poison might have repeated the experiments and proved the error of their predecessors, if they could. Little need here be said of these experiments, beyond noting that they furnish a strict parallel to those which other workers have made with lead. The possibility of degeneration has been separately demonstrated for the case of each parent, male and female; and in the case of the latter, the poison, when given during gestation, has been found to have passed into the blood of the offspring.

One point of special interest arises, however, for therein these experiments confirm what we observe in the case of our own species. It is that the poison affects, above all, the nervous system of the offspring. It is not the bones or the muscles, for instance, but the nervous co-ordination which enables the young creature to use its

muscles, that we find injured. Everything seems to show what we might have expected *a priori*, that the action of the poison in the germ-plasm is greatest upon those unknown and mysterious constituents of the germ-cells from which the nervous system, the highest and most delicate part, of the future individual will be formed; and, further, it is the highest, latest, most delicate part of the nervous system that suffers most. Thus, in puppies, as Combemale observed, it was the developing instincts and simple intelligence of the young creatures that were most defective. As upon the individual, so upon the offspring, the action of this poison is most marked in the highest tissues of all.

The Probable Action of Alcohol Through a Process of Fermentation

If we ask exactly *how* this action upon the germ-plasm is effected, we have as yet nothing more to guide us than the pioneer experiments made by Macdougal in New York upon plants. There he found that various chemical agents can modify the germ-cells in the parent, so that the type and characters of the young plants are remarkably altered—not necessarily, with some agents, in any morbid direction.

We can only speculate as to the case of alcohol in animals. But we know one or two suggestive facts, which may permit us to formulate a provisional theory. Briefly, it is this. The "factors" in the germ-cells, which the Mendelians are beginning to distinguish, seem to be of the nature of ferments. They cannot, however, be actual ferments in the germ-cells, any more than the blood can contain the blood-clotting ferment as such, for it would at once clot the blood. In the blood, and in the germ-cells, ferments which are not then and there to act must exist in the form of what are nowadays called pro-ferments—substances which only need a slight chemical change in order to be turned into active, fully formed ferments.

The Retarding Action of Alcohol on All Forms of Fermentation

Now, it has long been known that alcohol interferes with all forms of fermentation—even with that by which it is itself produced. Hence we may suppose that the action of alcohol in the germ-cells, or upon the process of gametogenesis, by which the "mature" germ-cells are formed in the parental body, is one of arrest upon the activity and perhaps upon the proper development of the ferments, or pro-ferments, and especially those which are destined to initiate the proper development of the nervous system of the individual formed from the germ-cells in question.

We all tend to think in grooves, and to repeat our predecessors' experiments rather than invent new ones of our own. It so happens that students of this subject have always proceeded by observing the quality of the offspring merely, and it has never occurred to them to study the germ-plasm of alcoholised animals in regard to its microscopic characters. Such a study would be perfectly simple, and would only be parallel to the microscopic study of other alcoholised tissues, which has been proceeding for decades. But, curiously enough, no one of these experimenters has made—or, at any rate, recorded—a single observation of this kind. Not until three years ago did we have the first record of microscopic study of alcoholic degeneration of the germ-plasm, not in the lower animals, but in human beings. The microscope had long ago detected and described alcoholic changes in the liver, the kidneys, the blood-vessels, the brain, and medical students have had to learn how to recognise such changes; but it had occurred to no one to examine the tissues which, from the point of view of posterity, are the most important of all—those from which all mankind to come must spring. It was a remarkable omission, and it illustrates the strange lack of the eugenic point of view in the medical sciences until the most recent years.

Microscopic Proof of the Degeneration of the Germ-Plasm Through Alcoholism

In 1909, at the International Congress on Alcoholism, held in London, Dr. E. Bertholet, of Lausanne, to whom students of this subject are greatly indebted, read a paper, comprising a few microscopic sections, in which he showed that, in a preliminary inquiry, it was possible to detect definite signs of degeneration in the germ-plasm as a result of alcoholism. These degenerative changes were quite similar to those seen in other tissues—inflammation, increase of the supporting and connective fibres, and swelling and destruction of the essential cells. It is what we see in the liver or the brain, or the heart or the kidneys. This paper aroused great interest, but the cases were few, and the author professed to make no more than a preliminary note upon the subject. Two years later, at the International Congress, held at the Hague, Dr. Bertholet read, before the most crowded and important audience of the Congress, a long paper, comprising the record of

microscopic examination in a large number of cases of both sexes. At the same session a long paper was read, with many photographs of idiots, monsters, and defectives, to demonstrate the racial poisoning produced by alcohol, but the whole was worthless as evidence, because the initial fallacy was not guarded against of observing stocks which already were defective.

No such objection could be taken to the splendid and original work of Dr. Bertholet. In it we were provided with indisputable, visual evidence of the blastophthoria which Professor Forel has long inferred from his clinical observations upon the descendants of alcoholics. Dr. Bertholet's paper constitutes one of the most important documents in the modern literature of alcoholism.

It was pointed out some time ago that we must distinguish between what we may call, respectively, acute and chronic blastophthoria. Many observers believe in the existence of both—that is to say, they believe not only that alcohol may cause degeneration of the germ-plasm by long-continued action, but also that a single bout of intoxication may have its consequence in the offspring.

The Undoubted Tendency of Alcoholism to Produce Sterility

On this question we would only note that we must be cautious before we content ourselves with a definite beliefs. The observations of Dr. Bertholet all deal with chronic blastophthoria; and, as in other cases of chronic alcoholic degeneration of tissues, the action of the poison usually seems to require that it be continued for a considerable period.

The only other point which we must note before leaving the work of Bertholet is that, according to his observations, the final result of chronic alcoholism is to produce such cellular degeneration in the germ-plasm that its possibilities are put an end to. The individual in whom this degeneration has occurred will not become a parent. In short, the poison produces sterility, as lead does, only that alcohol probably takes years to do what lead does in months. It would probably be better for the race if the process of germ-plasm degeneration induced by alcohol were more abrupt, so that sterility was produced at once, if any damage at all were done. Judging by the evidence of Bertholet, which is admittedly the first of its indispensable kind, we may believe that the dysgenic action of alcohol is exerted during only an intermediate period in the history of the drinker. Years may possibly have to elapse before the poison injures the germ-plasm; and in a few years thereafter the injury may be so extreme that, in a sense, it no longer matters, for the individual will have become infertile.

Here, no doubt, is one of the answers to the argument of Mr. Archdall Reid—that if alcohol injured the race we should none of us be here, so drunken were our ancestors. For it may be that the survivors are either the offspring of sober ancestors, or else are the earlier offspring of drunken ancestors. The defective portion of the community, in so far as alcoholism had produced it, would be that produced during the intermediate period of its action upon the germ-plasm of any individual parent. Here we have, when we go to the facts, instead of disdaining them, a simple enough answer to the *a priori* argument.

Finnish Studies of the Effects of Alcoholism on Family Life

Professor Taav Laitinen, of the University of Helsingfors, undoubtedly has the honour of being the first investigator to tackle this question properly, as regards our own species. His results have been contributed to the last two International Congresses on Alcoholism. They were not obtained by mathematical analysis of other people's irrelevant statistics, but by first-hand work. He saw that it would be necessary to take a community of reasonably small size, so that the whole of it could be studied. He did so himself, observing a village in Finland where all the population lived under practically similar conditions, and where each family could be individually studied in detail. Seven years of his life he devoted to this task of definitely ascertaining the influence of alcoholism upon the offspring. His personal observations upon this village were also supplemented by the results of a large number of similar observations made by his professional brethren in Finland at his request.

The Agreement in Results from all Methods of First-Hand Study

The results of the two sets of studies were in agreement with each other, and with every first-hand study on this subject that has yet been made—down to the incidental observations of Dr. Davenport and Dr. Weeks in their study of epilepsy, lately published by the Eugenics Record Office in America.

Laitinen divided his parents into three categories—teetotallers, moderate drinkers, and heavy drinkers. Of course, the two latter categories are vague and unscientific,

but that is not the fault of science, which would much prefer to study alcoholism as it studies plumbism or mercurialism, dividing mankind into those who take the poison and those who do not. But in this case we have to try to make a kind of convenient artificial division between those who—we fancy or they fancy—just use alcohol reasonably and those who admittedly abuse it.

Having in his knowledge the records of his own admirable experiments of previous years upon parental alcoholism in the lower animals, Laitinen was able to compare them with the results he obtained from these observations upon man. The records agree.

The Clear Advantage on the Side of the Non-Drinker

In man Laitinen found that the children of the non-drinkers had the advantage in all the respects examined ; that the children of the moderate drinkers, who doubtless call themselves the " true temperance " party, came next, and the children of the heavy drinkers last. He observed such data as the death-rate among the children, their height and weight at different ages, the number of teeth the infants had cut at certain ages, their susceptibility to disease, the incidence of epilepsy, etc. On all these counts the verdict went as might have been expected.

From the practical point of view we need no more details than such a piece of work affords us. From the purely scientific point of view we are, however, required to observe that Laitinen's work does not enable us to define with exactness the influence of alcohol upon the germ-plasm, for the evident reason that his observations comprise its influence on so much more than the germ-plasm—for instance, upon lactation, upon the nutrition of the expectant mother, upon the quality of the home, and so forth. The meaning of his results, for the Eugenist, is obvious, however, and we cannot be too grateful for them. Already—in Norway, at any rate—they have contributed towards legislation of a valuable kind, as we are about to see.

An Original Norwegian Study of Alcoholic Effects

By general admission, the most original and valuable paper read before the International Eugenics Congress in London in 1912 was that entitled " The Influence of Alcohol upon the Germ-Plasm," read by Dr. Alfred Mjöen, of Christiania. Dr. Mjöen first went over the results of his predecessors in this study, and particularly noted the fact that the most definite and serious evidence of racial poisoning had been found by those experimenters who had used *strong* alcoholic liquors. Such comparison as we can make upon the records of human cases leads also to the conclusion that the influence of alcohol upon the germ-plasm is very largely dependent upon the percentage of alcohol in the blood of the drinker.

Dr. Mjöen has further made several observations of his own, following the principles laid down by the present writer in an early number of the " Eugenics Review," in order to distinguish between the various ways in which parental alcoholism may affect the offspring. For, though Laitinen's work was splendid, we need a method which will enable us to discriminate between the influence of the father and of the mother and between the various ways in which the mother may affect her offspring. The kind of evidence adduced by Dr. Mjöen may be illustrated by a pedigree of four generations which he threw upon the screen. The ancestors of the alcoholic man were *all* exceptionally healthy, for at least two generations ; their average age at death was nearer ninety than eighty. This healthy man, with such ancestry, married a healthy woman. Their first child was normal, and is now alive and healthy. The man then became a drunkard, and had three more children, of which the first was weakly, and died in childhood ; the second was much worse, showing physical and mental defect, and the third was born dead.

Graduated Taxation of Drinks According to Their Alcoholic Potency

It is such pedigrees, where the " method of correlation," confusing different stocks, is not employed, that give us the crucial information we require. Upon such evidence Dr. Mjöen, and many medical men in Norway, have for some years past demanded " temperance legislation " of a novel kind, and on a novel principle. If people must drink, and if the State taxes their drink, let it tax most heavily the drink which contains most alcohol. In this way people will be encouraged to drink the lighter rather than the heavier forms of alcoholic beverage; and while the individual can scarcely be worse in consequence, our evidence strongly suggests that the race will be in much less danger. It was therefore proposed by Dr. Mjöen and his supporters that a system of graduated taxation on these lines should be introduced in Norway; and a fortnight before the meeting of the Eugenics Congress the Norwegian Storthing adopted the proposal—a very remarkable development of eugenic opinion in the comparatively small number of years since the eugenic movement began.

THE GROUPING OF STARS

The Drawing Together of Suns in Doubles, and Double-Doubles, and Unexplained Clusters

NEW WONDERS SEEN IN THE FIELD-GLASS

THERE are in the heavens a great number of stars which appear single to ordinary vision, but when studied with the aid of a good telescope are found to consist of two separate companions whose destinies are permanently linked together. These wedded stars are of great variety and of extraordinary interest.

Not all the pairs which appear so at first sight are really united in this way. With the increasing power of modern instruments the discovery of "double stars," as they are called, has proceeded rapidly; but at the same time many stars which appeared in smaller telescopes to be in extremely close proximity have been shown by these great magnifiers to be at considerable distances from one another, so that their apparent union was probably no more than an optical effect. Yet the occurrence of two stars really close to one another is far too frequent to be merely accidental or merely optical, and further observation of these remarkable couples has established beyond all doubt the fact of real physical relation in many of them. It is probable that the great majority of couples will eventually be proved to be indissolubly united. To the end of time these pairs of stars will present to the unaided eye but a single point of light. The two members of a couple can never be separated or pursue motions independent of one another, and consequently can never be so far apart as to become divided to ordinary vision.

Each of these physically related pairs forms what is known as a binary system. Such double stars represent a state of things notably different from the single dominion of our sun in the solar system; they consist of two suns, mutually circling about one another, and possibly themselves the centre of an unseen system of planets. How planets would perform their orbital movements around two bodies thus mutually revolving is very difficult to imagine, and presents mathematical questions of great complexity. Whether each sun would have its own set of planets, small enough and near enough to be practically undisturbed by the other, or whether the planets of a binary system would perform complex movements at a considerable distance about the two bodies at once, or whether they might be subject to some sort of alternating attraction, only actual discovery can show us.

All that we know at present is that these binary systems of two mutually revolving suns are extremely numerous in the heavens; indeed, it is highly probable that at least one star in five or six, and very likely a much larger proportion, is of this nature. The majority of couples, however, are much too close together to be divided by any telescope, and we only know that they are binaries by means of the spectroscope. The number of telescopic binaries known to be in actual revolution is upward of a thousand; but over fourteen hundred couples consist of members so close together as to have between them only an angular distance of two seconds or less; and in many other cases where the distance between the pair is greater than this there are proofs of real systemic relation hardly less conclusive than an ascertained mutual revolution would be.

Physical agreement forms a strong proof of real affinity between the members of an apparent couple. When two stars which are very close together in a telescopic view of the heavens present a striking similarity or contrast or harmony in colours, it may usually be concluded that they are physically united—that is to say, that they form a single system, and are in mutual revolution. This assurance is greatly strengthened when the two stars

are found to undergo simultaneous or regularly alternating changes in colour. For example, both Antares, the chief star in the Scorpion, and also the chief star in Hercules, are deep red stars, the first with a sea-green, the second with an emerald-green satellite. This combination was in each case sufficient in itself to convince astronomers of the existence of a physical relation between the red and the green star, and the companion stars have since turned out to be in both cases in mutual though extremely slow revolution.

Relationships of Stars are those Probably Based on Physical Affinities

Other cases of coloured pairs known to revolve around one another have been found in the constellations of Cassiopeia, Boötes, Cepheus, and Cygnus ; and it is regarded as probable that physical affinity will be found to underlie the colour harmonies of all pairs in close proximity to one another. Some doubt has been thrown on the existence of such real relationship in several particular cases, but no conclusive evidence is as yet forthcoming with regard to these.

Similarly, two stars close together which undergo light-changes in concert or in regular alternation may be taken to be really in union with one another ; either both brighten together, or one becomes brighter and the other duller, and then the position is reversed. It is very unusual, although one possible example in the constellation Cygnus is known, for only one star of a binary system to vary while the other remains constant.

The crowning proof of real physical union in double stars is, however, the evidence of orbital motion. Stars which can be ascertained to revolve round one another are unquestionably related as the members of an indissoluble system—indissoluble, that is to say, in the ordinary sense, for, of course, some catastrophe from outside might break up the system.

The Extreme Difficulty of Measuring Orbital Movements at Immense Distances

The discovery of these orbital movements has opened up a possible avenue to a great wealth of information concerning the stars. If once the relative movements of double stars could be measured, their masses in proportion to one another could be ascertained, and much would thereby be learned as to their light-giving qualities. But the difficulties in the way of measurements of this kind are at present well-nigh insuperable.

In the first place, the actual records of relative movement are liable to enormous error, for a displacement which is hardly observable even in the largest telescope represents a real motion through thousands of millions of miles. An entire orbit, occupying in some cases a computed period of thousands of years for its fulfilment, would trace out for us, if projected upon the heavens, an infinitesimally small ellipse, even if it could be followed by the most powerful instrument. The application of photography has in certain cases, however, solved most of the difficulty arising from the probability of error. Where the component stars of a binary system are far enough apart and sufficiently equal in brilliancy to give distinct images on a plate, photographic records at regular intervals ought in time to provide a complete record of the mutual revolution of the two stars, and records of this kind could be trusted to be free from any considerable error. But the photographic method fails when the two stars are closer together than two seconds, for in that case their images become confused on the plate ; and it fails again when one star is considerably brighter than the other, for then it is impossible to obtain any print of the duller star.

The Difficulty of Estimating the Rapidity of Orbital Movement

It remains possible, however, to investigate by means of photography all stellar orbits in which the binaries are of fairly equal brilliancy, and at a distance of two seconds.

But greater difficulties remain. The orbit thus secured gives us, not two distinct figures tracing the individual real paths of the two stars, but one composite ellipse representing the successive mutual positions of the stars, and made up, therefore, of the combined real movements of the two. It could only give the actual movements if one body were perpetually at rest and the other moved around it. But this, as we know, is never the case. Influence is always mutual, the amount of motion produced in each of the two bodies varying inversely as its mass. In every system whatever, *all* the bodies are in motion, each performing movements corresponding in kind to those which it produces in others ; but the extent and rapidity of the movements of each depend upon its relative mass. Thus, our sun himself moves in an orbit similar in form to the orbit of each of the planets of his system, but very many times smaller. In binary systems the two stars, though often unequal, have never anything like the inequality which exists between our sun and even his largest planet, so that the resultant

ellipse showing the mutual revolutions of the two stars does not even approximately show the amount of movement of either star, though it does represent the shape of the orbit pursued by each. In binary systems the two stars revolve round one another in orbits of exactly similar form and are always at diametrically opposite points in these orbits—that is to say, at either end of a straight line drawn through their common focus. But to dissever the motions of the two is a task of extreme difficulty and most laborious, and can hardly be said to have been fairly begun as yet. There are, however, several cases in which it has been possible to determine these motions with a considerable degree of certainty.

There is a double star in the constellation of the Virgin which consists of two third-magnitude stars. These two stars fluctuate alternately in light, each in turn losing about half a magnitude. They perform a complete revolution about one another in 180 years, and it has been computed that the real orbits of the two are equal and in the form of a much elongated ellipse. These two stars are therefore of equal masses.

The Most Convenient Double Stars for Studying Orbital Revolutions

The chief star in the Centaur, a southern constellation, is one of the three brightest stars in the whole heavens, and was discovered to be double as early as 1689. It is nearer to us than any other double star, and this makes it specially valuable for purposes of observation. The component stars are seen further apart than usual ; indeed, there is only one known binary in which they are more widely separated. The real distance between the Centaur pair is over eleven times the distance between the sun and the earth ; the Cygnus pair are separated by over sixty-five times the same unit. Other binaries are known to be actually more widely separated than the Centaur stars, but we can never see them so. The facts that both the component stars are exceedingly bright, that they are distinctly separate, and that they are near enough to us for their distance to be ascertained, make this pair not only much easier to observe than most others, but also much more productive of real results. Moreover, they have been under observation for a considerable length of time. The period of revolution in this system is between eighty-five and eighty-eight years, and the combined orbit is an ellipse not nearly so much elongated as that of the double star in the Virgin. The two stars are found to pursue equal orbits, and are therefore of equal mass, yet one of them gives three times as much light as the other.

This is one of the few double stars near enough to the earth for its distance to be ascertained. This distance is such that light would take four years and four months to traverse it—that is to say, it is more than two hundred and eighty thousand times the distance between the sun and the earth. The total mass of the two stars is nearly twice the mass of our sun.

The Extraordinary Double Character of the Brilliant Star Sirius

Only seven double stars have been measured successfully, and with any real precision with regard to distance, orbital movements, and masses. The Centaur pair just described is one of these. Sirius is another, but he has not been known as a binary for anything like as long. It was in 1844 that Bessel, when studying the movement of Sirius in the heavens, found traces of the influence of an unseen satellite in regular periodic undulations in the star's motion. The disturbing body itself was discovered in 1862. It forms an amazing contrast with the glorious white luminary which it influences. It is of a dull yellow colour, and fails to attain even to the eighth magnitude, yet the mass of this dusky insignificant star is found to be very considerable. It is, in fact, almost half as massive as Sirius himself, the two together making up a mass three and a half times that of the sun.

The contrast of these two bodies is remarkable—one star is about twice as massive as our sun and at least sixty-three times as brilliant ; the other gives only about one one-hundred-and-sixtieth of the sun's light, though almost equalling him in mass.

The Balancing of the Double Stars of Sirius on Their Centre of Gravity

Sirius is distant from us about fifty billion miles, and the two stars of his system rotate in a period of fifty-eight and a half years. The orbit is considerably eccentric, more so than that of the Centaur pair, but not nearly so much so as that of the double star in the Virgin. The two stars are separated by a mean distance of more than twenty-two times the distance between the sun and the earth, and perform similar orbits of very unequal sizes, but are invariably diametrically opposite to one another, exactly as in the case of doubles pursuing equal orbits. The orbits may be represented diagrammatically by two intersecting rings of exactly similar form but of different sizes,

and having the major axis of both in the same straight line. Along the path of Sirius through space, the centre of gravity of the whole system moves undisturbed in a direct course, the two stars being always at distances from it in a certain unvarying ratio to one another, corresponding to their respective masses.

The first double star to be discovered was Mizar, so called by the Arabians, one of the chief stars in the Great Bear, or the " middle horse of the Plough." As early as 1650 it was known that Mizar consisted of two stars, of the third and fourth magnitude respectively. These stars are far enough apart to be seen distinct from one another in a moderately strong telescope. Their orbit has been computed to occupy a period of something like ten thousand years. This system is of unusual interest on account of other stars which are involved in it, of which we shall speak later.

Another pair easily resolvable in a good telescope is the brilliant star Castor, illustrated on page 3783, in the constellation Gemini, consisting of two bright white stars tinged slightly with green, one of the second, the other of third magnitude. These two stars revolve in a highly eccentric orbit requiring about one thousand years for its completion; they are twice as far from one another at their greatest as at their least distance.

Double Stars that Take Eight Centuries to Travel Their Orbit

The largest known orbital movement in binary stars is the path of the Cygnus pair referred to above. The mean radius, or half the major axis, of the ellipse which it traverses is computed to be sixty-five and a half times the distance between the earth and the sun. This enormous path requires nearly eight centuries for its fulfilment, the motion of the component stars being slower than the motion of our earth in her orbit. This proves that the mass of these stars is considerably less than that of our sun; indeed, the mass of the two together probably does not amount to one-half the mass of the sun. They are also proportionately much less bright than he is.

Out of about sixty binary systems of which the orbits have been computed, only eleven have periods of less than fifty years; only twenty-six altogether, including the above eleven, have periods of less than one hundred years; while for some of the slowest-moving couples, in which the traces of orbital movement are hardly discernible, periods on such a scale as twenty thousand years have been assigned. The quickest moving of all so far known is a pair in Equuleus which revolves in a period of between eleven and fourteen years.

All the stars which we have so far been discussing are clearly of a double nature when they are observed in the great telescopes. But many are known to be true binaries which never can be seen, even with the most powerful instruments, as anything but single points of light. They are either too distant from us, or are too close together, to be separated to our view. Yet their double nature is indubitably revealed to us by the spectroscope.

Stars Known as Compound, though the Largest Telescopes will not Separate Them

Stars which appear single in the largest telescopes may be known, from changes in their spectra, to be compound. These changes consist in regular periodic shiftings of the lines of the spectra to right and left across their normal position—or, rather, across an average position which is not exactly the normal on account of a constant movement of the double star either towards or away from our solar system.

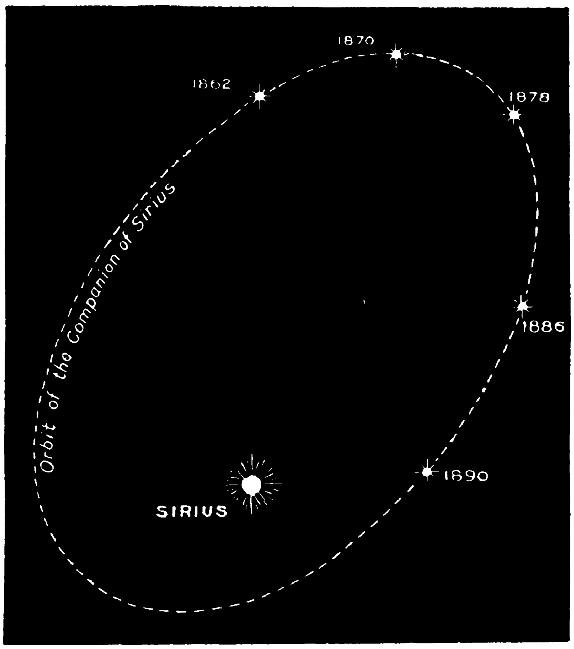
We have seen in an earlier chapter that if a luminous body be approaching the observer, the lines of its spectrum are shifted towards the violet, to a distance proportionate to the speed of the approach; and, conversely, if the source of light be receding from the observer, the lines of its spectrum are shifted towards the red. If, therefore, a star be moving in an orbit, and the plane of that orbit be more or less in the line of vision, it is alternately approaching and receding from the earth, and the lines of its spectrum must shift alternately towards the violet and towards the red ends of the spectrum. If two bright stars be in mutual revolution, the spectral lines appear double at two points in each revolution—namely, when the component stars are furthest apart as seen by us, and one of them is receding from us and the other is approaching us.

How We See in the Spectroscope What Can Never Be Seen in the Heavens

The lines due to one star are moved along towards the violet by its motion toward us, and the lines due to the companion star are displaced toward the red by its motion away from us. But at other points in their orbital revolution, when the stars are moving across the line of vision, one to the right and the other to the left, and neither is approaching us nor receding from us, the lines of their spectra are no longer double, but coincide.

Thus the completion of one revolution is measured in the spectroscope by two doublings of the spectral lines and two returns to a single set of lines. If, however, one of the two bodies be dark, it cannot reveal its presence directly by lines in the spectrum, but its existence may be detected by the evidence of orbital motion in the spectrum of the bright star. This is shown by the same shiftings of the lines, from their normal position, towards the red and towards the violet; but in this case there is, of course, no doubling of the lines. The spectral lines are displaced first to one side and then to the other, the course of an entire orbital revolution being marked by one complete swing in the two directions. Thus the spectra of stars reveal to us not only their double nature, but also the length of time taken in accomplishing their orbital revolutions. There are, of course, all grades of unequal luminosity in double stars, and these appear in their spectra as lines more or less unequally marked.

The spectroscopic study of double stars has brought out many interesting and significant facts. For instance, in the case of coloured pairs showing changes in colour, the spectra have several times been found to register, apparently, not present but former conditions. Or, rather, it may be suggested that they register a more permanent and fundamental condition, while present colours are produced by more temporary and superficial conditions. For example, in the case of the two companions forming the star known as 95 Herculis, which have frequently been recorded as appearing green and red, but are now both primrose yellow, the two spectra are now not alike but different, one being of the Sirian and the other of the solar type. We can hardly avoid the conclusion that the Sirian spectrum is that of the former green star, and the solar spectrum that of the former red star, and it seems likely these colours will again recur in the two stars which compose this pair. Other similar examples are on record.



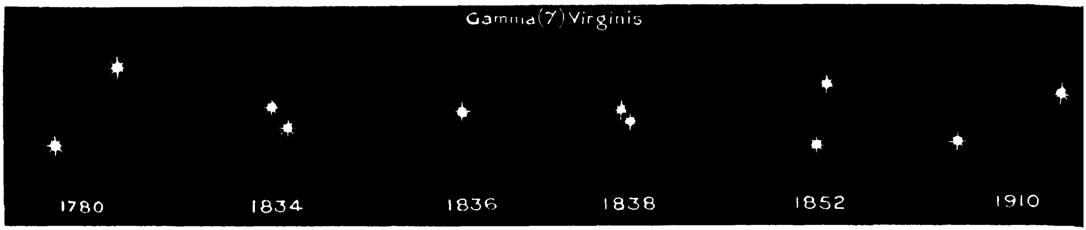
THE ORBIT OF SIRIUS'S COMPANION

This diagram shows the orbit as it appears from the earth, and the position of the companion star in several successive years.

Capella is a most interesting star. Down to the year 1899 it was regarded as the model solar star, presenting a close analogy with our own sun; and spectroscopic observations only confirmed that impression, for no indications could be found of any constitutional difference from the sun. With the greatly improved instruments at Lick Observatory, however, many fresh details came out in the spectrum, which was soon discovered to be of a compound nature, and to bear unmistakable traces of shifting movements towards the red and the violet. Capella became the subject of engrossing investigation, and the knowledge of its double nature overturned what had been supposed to be its perfectly established character as the counterpart of our sun. It was found to be a binary system composed of two stars about equal in mass but of unequal brilliancy. One of these stars shows a true solar spectrum, the other a spectrum intermediate between the solar and Sirian types. The latter is much the fainter, being of not more than half the brilliancy of the solar star. The system of Capella is near enough to us for its distance to be determined with a strong presumption of accuracy. It is estimated at forty light-years—that is to say, a distance which light would take forty years to travel. These two stars circulate round one another at a distance somewhat greater than that of the earth from the sun, and the plane of their orbit is calculated to lie at an angle of sixty degrees to the line of sight.

As we have already noted when considering short-period, variable stars, there are a large number of binary systems consisting of one bright and one dark member. The dark member reveals itself

by periodically eclipsing its bright companion in variables of the Algol type. The study of double stars tends to support the conjecture that dark bodies are extremely numerous in the heavens and are very frequently associated with bright stars. As the motions of the stars come under more accurate observation, the influence of unseen bodies is more and more largely discovered. Occasionally the position and movements of such system—that is to say, there are not two or three bodies revolving with similar motions around a central body. In the stellar systems we always find either two stars revolving about one another and pursuing at the same time an orbit around a central star, or two central stars in mutual revolution with a subordinate star circling round them; or, again, we get two doubles united in a common systemic motion. A system of immeasurable vast-

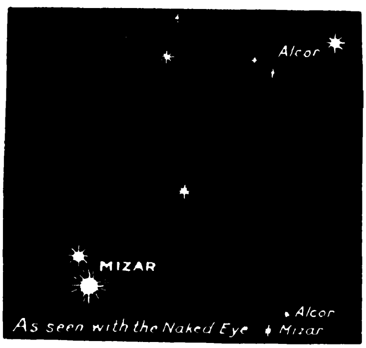


THE VARIED APPEARANCES OF THE DOUBLE STAR GAMMA VIRGINIS IN THE COURSE OF 130 YEARS

These two stars perform a complete revolution round each other in a period of 180 years. Their orbits appear to take the form of an elongated ellipse. A remarkable circumstance was their coming together in the line of sight in the year 1836.

bodies can be conjecturally determined; and those determinations have been triumphantly established in the cases of Sirius and Procyon, the greater and lesser Dog Stars, by the discovery of very dully luminous satellite bodies in the positions indicated by mathematical calculation.

As is only to be expected, the searching observation of binary systems discloses a more and more complex variety of relations. Thus, Castor has been found to be accompanied by a small obscure satellite circling round the two great luminaries which form his centre; and, still more recently, the spectroscope has revealed the presence of an unseen satellite circling about the lesser of the two chief stars of Castor. Our familiar Pole Star has two dark companions. Systems of three or four suns, or even a larger number, in related movement with one another, are being discovered in increasing numbers. The relations of such stars present a great range of variety; they are of immense interest, and give us a conception of vast movements and of tremendous rhythm and order beyond all analysis.



MIZAR, THE DOUBLE STAR IN THE TAIL OF THE GREAT BEAR

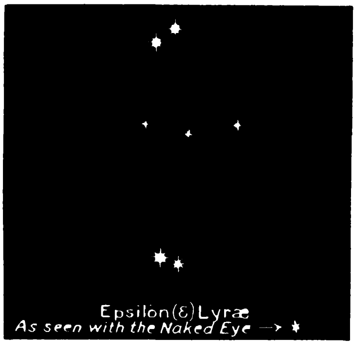
The relation of three or four stars in a single system is not ever, so far as has been made out at present, of the same nature as the relations of the planets in the solar

ness and majesty is revealed in the motions of the star known as Epsilon Lyræ. To the naked eye this system appears as a single fourth-magnitude star; but a three-inch telescope suffices to show us all the four component stars, in two pairs, each pair being in mutual revolution in itself, and the two pairs performing a vast orbital movement around one another. None of these orbits can be even conjecturally measured with any precision; the period of one pair is estimated roughly at about one thousand years, and of the other at about two thousand years; while the orbital motion of the whole system is beyond all attempts at the roughest estimation. Yet the evidence of the reality of these complex systemic movements of the entire system is indisputable. The two pairs not only have each real movements of their own; they are also in actual revolution with regard to one another, though this motion, as we see it, amounts only to nine seconds in a hundred years.

This wonderful system is not singular in the heavens. Already more than twenty similar "double-doubles" are known, and it is likely that many more, at present known as binaries, will be found to be of a more complex order. One or two combinations of four stars deserve special

notice as forming systems of a less evenly balanced kind. One of these, Mizar, in the Great Bear, has already been referred to.

In Mizar, which is single to unaided vision, we have a telescopic double, one member of which is itself a very close spectroscopic double. In some sort of relation to this close group, but at a distance sufficient to divide them even to the naked eye, is the star Alcor, known in America as the "rider" of the middle "horse" of the Plough. If, as is probable, though not quite certain, Alcor is actually dependent upon Mizar, we have here a very interesting system, consisting of a primary star, with a dependant inseparable from it by the telescope, another closely united to them but distinguishable from them by the telescope, and a third united to the others by physical relations but by no means in very close proximity.

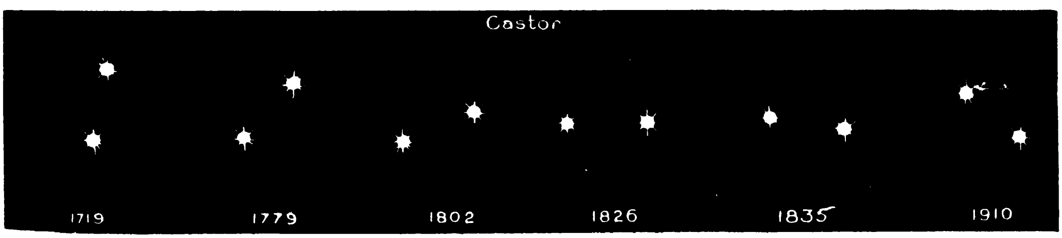


EPSILON LYRÆ
An example of two binaries revolving round a common centre of attraction. The three small stars lie far beyond.

There is a system in the constellation of the Crab which is even more interesting. This star, already known as a double, was discovered by Herschel, in 1781, to be of triple character, the smaller and more remote body having a movement around the closer pair, covering about half a degree in the course of a year. But certain regular retardations, quickenings, and cessations in its motion convinced Otto Struve that this smaller star was itself in relation with an invisible body greater than itself, around which it was circling. This has been proved by Seeliger to be actually the case. Most interesting of all is the suggestion that this dark body is itself the centre of the whole system, the three bright stars being in motion round it and two of them at the same time in revolution round one another. Miss Clerke sees in this star, known as Zeta Cancri, a possible example of an anti-Copernican system. "Here a cool, dark globe, clothed possibly with the vegetation appropriate to those strange climes, and plentifully stocked, it may be, with living things, is waited on, for the supply of their needs, by three vagrant suns, the motions of which it controls, while maintaining the dignity of its own comparative rest, or, rather, of its lesser degree of movement. For the preponderance of this unseen body cannot approach that of a sun over its planets; hence its central position is by no means undisturbed."

When colour-variations are also found in systems of multiple stars the effect is further heightened. Some beautiful examples occur. In Andromeda is a chrome-yellow star of slightly less than the second magnitude, with a companion of the fifth magnitude sea-green in colour. But this companion, when observed in a good telescope, is found to be itself a double star, consisting of a green and a blue component. These two stars are revolving in an ellipse which takes five hundred years to complete.

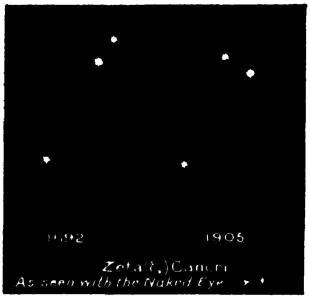
A swiftly moving group of three stars, the chief of which is between the fourth and fifth magnitudes, is found in the constellation Eridanus. The small double star which is attached to the chief star is so distant that their real union might be doubted but for the overwhelming evidence of the movement of the three in a swift and equal motion across the heavens. The satellites are at a distance of eighty-five seconds from their primary, and revolve about one another in 139 years. The mass of these two is more than twice the mass of our sun, but they give less than one-thirtieth of his light. This fact is of considerable interest in relation to the swiftness of their movements, for it has been conjectured



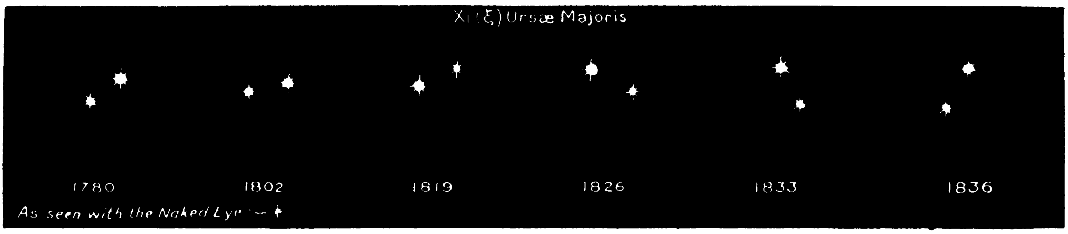
CASTOR, THE BRIGHTEST STAR IN GEMINI, ONE OF THE BEST KNOWN BINARIES
These two stars, which can be readily seen to be double through a small telescope, revolve round each other once in about 9[illegible] years. Their relative positions in the last 200 years are here shown, and they will be seen to have performed scarcely one quarter of their revolution.

on various grounds, especially with regard to the relations between brilliancy and motion in certain classes of stars, that there may exist stars of very feeble luminosity but of great swiftness, forming to some extent a special class apart.

Star-couples may be presumed to be of equal age; therefore the relations which they show between size and physical condition as recorded in their spectra are of extreme interest. They are likely to throw considerable light on questions of stellar evolution. Already their evidence seems to tend to the reversal of the usual theory that development proceeds more slowly in a larger than in a smaller body. In the double star in the Virgin, the components of which are equal, the spectra of both are of Sirian type, and exactly similar. Hence they may be taken to have proceeded equally along the path of evolution. In the case of a good many other bright doubles, the spectra are found to be closely matched; thus, the star Castor consists of two stars of Sirian type, and the same are found in a bright double star in Auriga, and again in Mizar. In many other unequal couples, the spectrum of the larger star is of solar and that of the smaller is of Sirian type, as in Beta Cygni, in Gamma Andromedæ, and in Gamma Delphini; or, again, the larger is of Antarian type and the smaller of Sirian type, or in some cases, as in Procyon, midway between solar and Sirian. All these examples seem to indicate that the larger body has proceeded further along the evolutionary path—that is to say, that mass accelerates development. But there are examples which appear to indicate the opposite tendency. There are a considerable number of yellow stars, giving spectra of solar type, which have smaller companion bodies of a purple or rosy-violet colour, giving a vastly smaller proportion of light. The exact meaning of the colour of these satellites has not yet been discovered, but it is almost certain that this dull, rosy glow is the sign of old age, and that the bodies in which it appears are both greatly condensed and subject to considerable absorption of light. In these cases, the smaller body would seem to have proceeded much further than the larger—that is to say, that, being of equal age, it has developed more quickly. It is just possible, however, that these dim, deeply coloured satellites may prove, after all, to be of greater mass than their yellow solar primaries; and much more investigation is required before any definite conclusions can be drawn.



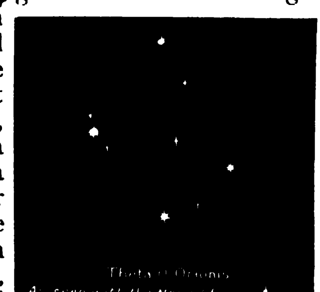
THE TRIPLE STAR OF ZETA CANCRI AT TWO DATES



XI URSÆ MAJORIS, A DOUBLE STAR IN ONE OF THE FEET OF THE GREAT BEAR

This star was the first calculated binary, and performs its revolution in sixty years. The alteration in their relative positions during the complete cycle which led to their discovery as forming a binary is here shown.

From the relation of two or more individual stars in a system, we pass to a system of two knots or groups of stars, an example of which is to be found in Orion. This is a third magnitude star near the middle star of Orion's belt, and is easily seen to be double with quite a small telescope. In 1779 Herschel observed it to be triple, and since then repeated observations have divided each component into an increasing number of stars. Another group of stars forming a multiple system is also found in Orion, and a similar one in a nebula in the same region. The nebulous nature of the whole realm of Orion is well known, and the prevalence of multiple stars or incipient star-clusters within it is noteworthy. It is believed by some astronomers that such multiple stars do, in fact, represent the advance-guard of the rising of a great cluster from out of the nebulous mass.


THE BEAUTIFUL MULTIPLE STAR IN ORION

IN THE MIDST OF THE EARTH

The World's Impressive Subterranean Hollowings and Cavernous Waterways

A DUSTLESS AND GERMLESS UNDERWORLD

Let us now consider the subject of caves. Though caves have not the grandeur of waterfalls, they have always appealed to the imagination of men. There is room in their shadowy grottoes for many dreams and many mysteries, for sibyls and nymphs, for fairies and gnomes, for Typhon and Cyclops. From caverns spake the oracles of Corinth and Delphi; into a cavern in a hill did the Pied Piper lead the dancing children; and a cavern in the hills of Granada still hides Boabadil and his Moors. But caves have appealed not only to the imagination, but also to the practical instincts of men; they have been used from time immemorial as dwelling-places, as fortresses, and as tombs. Lot went up from Zoar and dwelt in a cave, he and his two daughters; in caves kings of Canaan and kings of Scotland, freebooters, smugglers, and martyrs have found refuge from their foes. In a cave good Obadiah concealed a hundred prophets; in a cave Joshua imprisoned five kings. In the cave of Machpelah sleep Abraham and Sarah, Isaac and Rebekah, Jacob and Leah, and Joseph.

It is probable that whole races of Palæolithic men dwelt in caverns, kindling fires there, cooking food there, sharpening their flints there, drawing pictures of mammoths and bisons there. In Neolithic days multitudes of men inhabited the caves, and much of our knowledge of early man is derived from a study of the contents of such rocky chambers. Even still there are cave-dwellers to be found. In the Canary Islands, for instance, within a stone's-throw of large modern hotels, are natives of the islands who still live in caves.

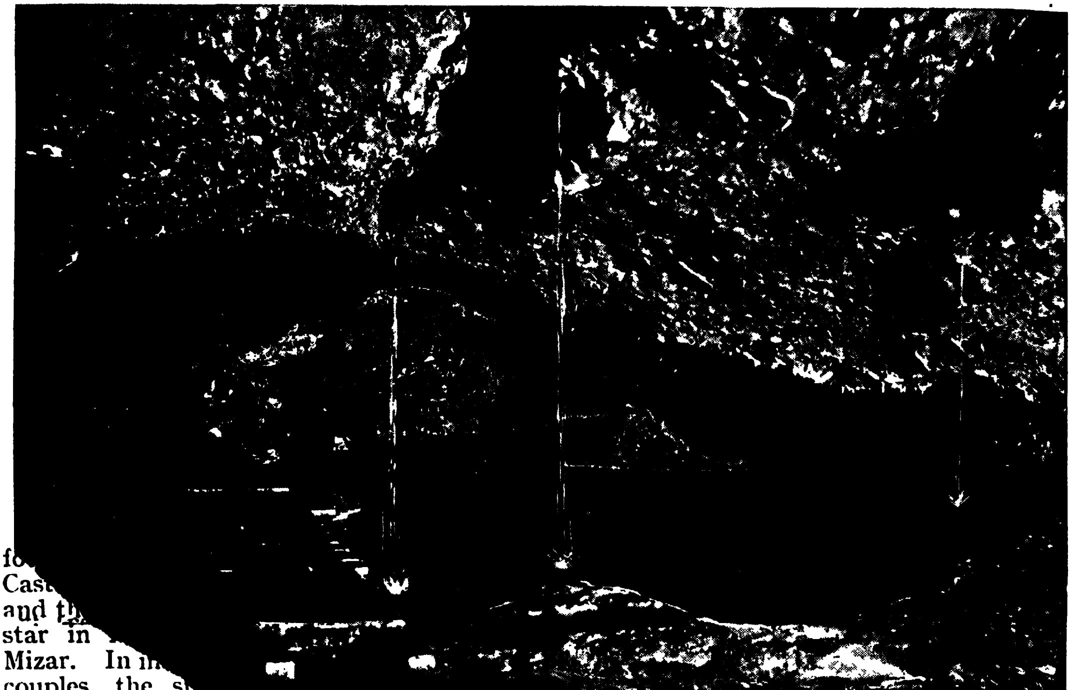
Burial caves, like dwelling caves, are found all the world over, and, like dwelling caves, have done much to throw light on the ways of primitive man. In the Cave of Ataruipe, in South America, Humboldt counted 600 skeletons and mummies preserved in baskets woven from the petioles of the palm-tree. Along with the skeletons and mummies were found sandals, and implements, and ornaments. In burial caves in the Aleutian Islands, Mr. W. H. Dall found mummies in a sitting posture which had been carefully wrapped in many wrappings. First came fine grass-wrapping ornamented with tufts of reindeers' hair and with feathers, then a second coarser wrapping, then a sack made of the skin of birds. Then came more mats, fine and coarse, then a packing of dry grass, then a covering of fine, large otter-skins. Finally the package was sewn together by a braided network of twisted sinews. Beside the mummies were found masks and effigies, awls and needles, axes and arrows. In a cave in Teneriffe were found more than a thousand mummies, which had been embalmed, sewn up in goatskins, and bandaged with leather.

In Egypt the caves in the rocks were sown with myriads of mummies, and in Italy are the Catacombs of Rome; but these are artificial excavations, and do n... rightly come under consideration here.

Many caves, known as bone cav... notable chiefly for the bones o... which they contain, and the li... throw on the biological ... country. In a cave at K... shire, Buckland discover... cave is found of no less than twen... island of Staffa. animals—hyæna, ... as a place. elephant, rhino... frame the temples decked ox, deer, ... earthly architect raven... herself, it seemed, would raise late... minster to her Maker's praise!
... not for a meaner use ascend
Her columns or her arches bend;
Nor of a theme less solemn tells
That mighty surge that ebbs and swells,
And still, between each awful pause,
From the high vault an answer draws,
In varied tone prolonged and high
That mocks the organ's melody.

In the famous Wookey Hole, near Wells, have been found the grizzly bear, the fox, the woolly rhinoceros, the great urus, the reindeer, the cave-lion, the brown bear, the badger, the rhinoceros, the bison, the red deer, the cave-bear, the wolf, the mammoth, the horse, the Irish elk, the lemming, and, last but not least, *man*. In Kent's Hole, near Torquay, the Rev. J. MacEnery found thousands of teeth and myriads of bones. The bones were so closely packed that they seemed more than sufficient to stock all the menageries in the world. The bone caves of Belgium are particularly rich in bones. The cave at Lunal-Viel, for instance, contains nearly one half of all the hundred-odd species that have been dis-

rhinoceroses along the slopes of the Mendips, till they scared them into the precipitous ravine, or watching until the strength of a disabled bear or lion ebbed away sufficiently to allow of its being overcome by their cowardly strength. Man appeared from time to time on the scene, a miserable savage armed with bow and spear, unacquainted with the metals, but defended from the cold by coats of skin. Sometimes he took possession of the den, and drove out the hyænas, for it is impossible for both to have lived in the same cave at the same time. He kindled his fires at the entrance, to cook his food and to keep away the wild animals, then he went away, and the hyænas came to their old abode."



fo
Cas
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star in
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couples, the s
larger star is of

LAKE AND ITS ISLAND IN WOOKEY HOLE CAVE, NEAR WELLS

of the smaller is o n the Gailenreuth Caves,
as in Beta Cygni, s of no less than 800
Andromedæ, and the Neanderthal Cave
Delphini; or, again, the lled "Neander-
is of Antarian type and th ith ape-like
smaller of Sirian type, or in
some cases, as in Procyon, that
midway between solar and
Sirian. All these examples seem THE BEAU
to indicate that the larger body STAR
has proceeded further along the evolutionary path—that is to say, that mass accelerates development. But there are examples which appear to indicate the opposite tendency. There are a considerable number

How do caves originate? How come these holes to be in the crust of the world? Caves originate in various ways—they may be volcanic in their origin; they may be excavated by the sea or by subterranean streams and rivers. Volcanic caves may be made in the crust of the earth simply by ejection of lava. In a single eruption a volcano may pour out millions of tons of lava, and, naturally, the ejection of this large amount of material must leave holes in the crust. Or they may be made in the lava itself by the shrinkage of its interior. Such "lava caves" are often of considerable cl.

size. There is one near the base of Monte Rossi about a mile long; and Professors Brewer and King explored a lava cave on the flank of Mount Shasta half a mile long, whose sides were dimpled with blister-holes and lined with lava-froth. The finest lava caves in the world are found in Iceland, and the finest of the Icelandic lava caves is the Surtsheller. The tremendous eruption of Skaptar Jökull in 1783 spread a torrent of lava over an area of 420 square miles, and in the centre of this enormous mass of lava is the Surtsheller lava cave. The cave is named after Surt, the Prince of Darkness of the Scandinavian mythology. It is entered through a chasm in the lava, and is about a mile in length, and for nearly 4000 feet is 40 feet high and 50 feet wide. Dr. Ebenezer Henderson, who explored the cave first, nearly a hundred years ago, says that: " The roof and sides of the cave were decorated with the most superb volcanic icicles, crystallised in every possible form, many of which rivalled in minuteness of beauty the finest zeolites, while from the floor rose pillars of the same substance, assuming all the curious and fantastic shapes imaginable, mocking the proudest specimens of art and counterfeiting many well-known objects of animated Nature. Many of them were upwards of four feet high, generally sharpened at the extremity, and about two feet in thickness. A more brilliant scene never presented itself to the human eye, nor was it easy to divest ourselves of the idea that we actually beheld one of the fairy scenes depicted in Eastern fable."

Marine caves made by the eroding action of the sea are very numerous. The most typical are made not in soft but in hard rocks, such as basalt. The soft rocks are broken down altogether; but the hard rocks are more resistent, and are eroded chiefly where there happens to be weaker spots in their armour. The high granite cliffs of Sark are honeycombed by caves, as are also the rugged coasts of Norway. One of the best specimens of a marine cave is found in Fingal's Cave, on the island of Staffa. It appealed to Scott as a place.


THE ENTRANCE TO THE GREAT PEAK CAVERN, IN DERBYSHIRE

Where as to shame the temples decked
By skill of earthly architect
Nature herself, it seemed, would raise
A minster to her Maker's praise!
Not for a meaner use ascend
Her columns or her arches bend;
Nor of a theme less solemn tells
That mighty surge that ebbs and swells,
And still, between each awful pause,
From the high vault an answer draws,
In varied tone prolonged and high
That mocks the organ's melody.

The island of Staffa consists of lava and basalt, and round its coasts are grouped immense basaltic pillars. Strong and hard though the pillars be, the sea has eaten into them in places, and has excavated several caves. Far the largest and most impressive of these caves is the cave that is known as Fingal's Cave. It is 371 feet long, 50 feet to 60 feet broad, and 70 feet to 117 feet high. It is not a large cave as caves go, but not its size but its architecture is its boast. Its roof is supported by ranges of great basaltic pillars about two feet in diameter, and having five or six sides, and both roof and floor show sections and stumps of columns that have been broken away by the sea. There is not "a single stone or fragment which is not prismatic, and symmetrically, perfectly, and regularly sculptured." Walls and roof, too, are beautifully polished, and reflect in places bright orange and emerald tints, which give varied beauty to the twilight in the interior of the cave. The Celtic name of the cave means "harmonious grotto," for the sea winds and sea waves harp on the great columns and make a low, sweet harmony.

Ocean has proved its strength, and of its grace
In calms is conscious, finding for his freight
Of softest music some responsive place.

The imaginative Celts beautifully say that the music is of Fingalian shadows playing on æolian harps.

We now come to the most interesting class of caves—those excavated in limestone rock by subterranean water. Anyone who has noticed the corrosive effect of the dripping of a siphon of soda-water upon a marble slab will readily understand how underground water, impregnated as it always is with carbonic acid, must in time corrode caves in the limestone rock. All over the world such caves exist, many of them beautiful and some colossal. For their beauty they depend chiefly on their stalagmites and stalactites, the calcareous concretions formed by the limy water dripping from their roofs and walls. In England the most remarkable of these limestone caverns are the Peak Cavern and Poole's Hole, in Derbyshire. The Peak Cavern is 2250 feet long, and has six large chambers. Much more remarkable, however, than these are the Adelsberg Grotto, in Carniola, and the Aggtelek Cave, in Hungary.

The Adelsberg Cavern, including its ramifications, is over five miles in extent, and disputes with the Aggtelek Cave the title of the longest in Europe. It may be

THE ENTRANCE TO THE FAMOUS MAMMOTH CAVE IN KENTUCKY

explored for more than two miles, and the River Poik, which penetrates it, can be followed for half a mile. The cavern expands here and there into chambers, and the largest of these chambers, the Franz Joseph and Elisabeth Grotto, is 223 yards long and 214 yards broad. W. H. Davenport Adams says, "There is not, perhaps, another cavern in the world so distinguished by a character of grandeur and boldness. The irregularities of its surface, the fissures torn in its vast sides, its deep shadows and gloomy hues, form a striking contrast with the regular beauty and symmetrical grace of the whitely gleaming and transparent concretions suspended to the roof, and reflecting in all directions the flashing light of torch and taper."

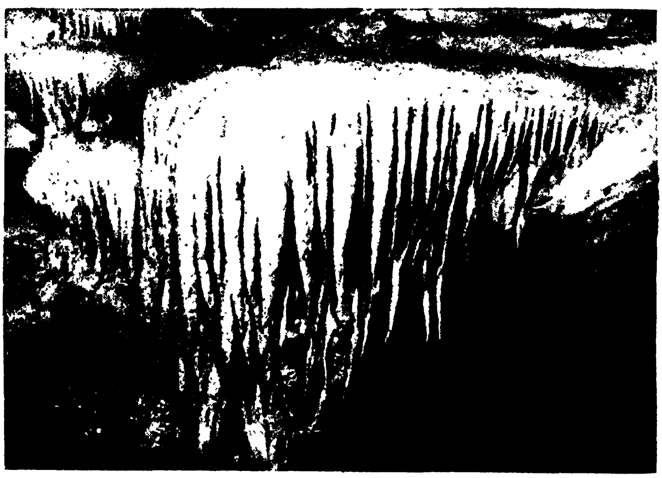
In the cave are found the curious animals called Proteæ, which have both gills and lungs, and which can live both under water and in air.

There are no other caverns in Europe so large as the Austro-Hungarian caverns we have just mentioned, but there are many caverns more beautiful. In France we have

THE STAR-CHAMBER IN THE MAMMOTH CAVE OF KENTUCKY

the Grotto of La Balme, the Grotto des Demoiselles, the Grottoes of Arcy, and the Grottoes of Osselle, all adorned with fantastic and beautiful stalagmites and stalactites. In Belgium we have the wonderful Grotto of Han-sur-Lesse. In Greece, in the island of Antiparos, we have the Grotto of Antiparos, which many consider the most beautiful stalactitic cavern in the world. It contains a superb stalagmite, 24 feet in height and about 20 feet in diameter at its base, which is known as "The Altar," since Mass was celebrated upon it in 1673.

The greatest limestone cave in the world is the Mammoth Cave, in Kentucky, with 223 known avenues, of an average width and height of seven yards, and of a total length of 150 miles, representing a total erosion of 12,000,000 cubic yards of limestone. Kentucky has a limestone area of 8000 square miles and about 500 known caves, but the Mammoth Cave is *facile princeps*. A French traveller making a tour of the world declared that no spectacle, not even the Niagara Falls, impressed him so much as this cave. Bayard Taylor said: "It is the greatest natural curiosity I have ever visited, Niagara not excepted; and he whose expectations are not satisfied by its marvellous avenues, domes, and sparry grottoes must either be a fool or a demigod."

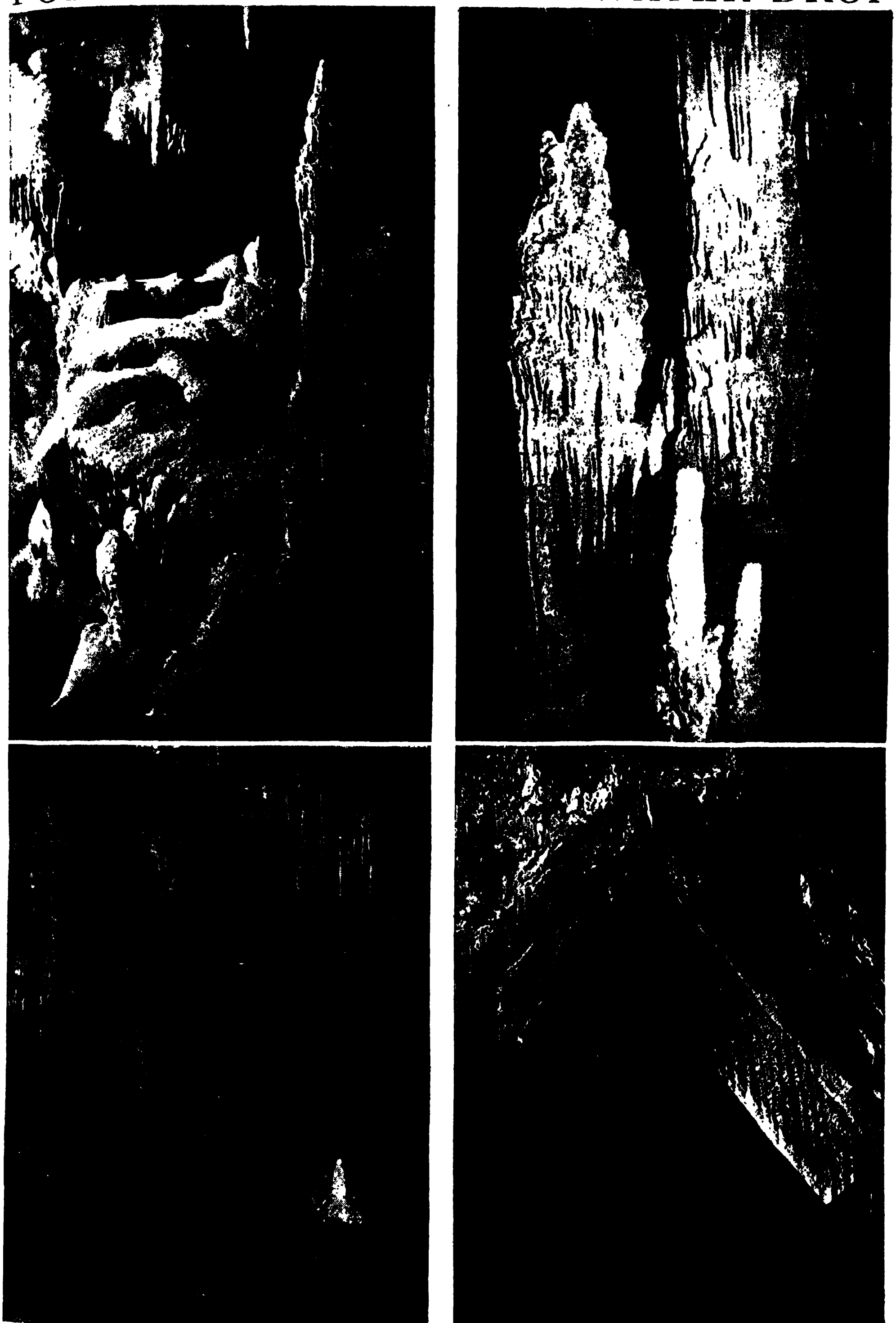

PILGRIM'S AVENUE IN THE MAMMOTH CAVE OF KENTUCKY

Naturally, in a cave of this size there are quite a multitude of chambers; about fifty-seven are known, and each has been given a distinctive name, such as the Gothic Church, Bacon Chambers, Ole Bull's Concert Room, Mary's Bower, Mary's Vineyard, Lucy's Dome, the Star Chamber, etc. The largest chamber, named the Chief City, is 450 feet long and 130 feet wide. Some of the chambers are very lofty—Stella Chamber and Mammoth Chamber are each about 250 feet high, and Lucy's Dome is over 300 feet high. The Elindo Avenue is 60 feet wide, 20 feet high, and two miles long; and, since it is considered the crowning marvel of the mighty cavern, Bayard Taylor's description of it may be quoted here:

"We first entered the Snowball Room, where the gnome children in their sports have peppered the grey walls and ceiling with thousands of snow-white projecting discs so perfect in their fragile beauty that they seemed ready to melt away under the blaze of your lamp. Then commences Cleveland's Cabinet, a gallery of crystals the richness and variety of which bewilder you. It is a subterranean conservatory filled with the flowers of all the zones, for there are few blossoms expanding on the upper earth but are mimicked in these Gardens of Darkness. I cannot lead you from niche to niche and from room to room examining in detail the enchanted growths; they are all so rich and so wonderful that the memory does not attempt to retain them. Sometimes the hard limestone rock is changed into a parterre of white roses; sometimes it is starred with opening daisies; the sunflowers spread their flat discs and rayed leaves; the feathery chalices of the cactus hang from the clefts; the night-blooming cereus opens securely her snowy cup, for the morning never comes to close it; the tulip is here a virgin, and knows not that her sisters above are clothed in the scarlet of shame.

"In many places the ceiling is covered with a mammary crystallisation, as if a myriad bubbles were rising beneath its glittering surface. Even on this jewelled soil which sparkles all around you grow lilies and roses, not singly overhead, but clustering together towards the base of the vault, where they give place to long, snowy, pendulous cactus flowers, which droop like a fringe around diamonded niches. Here you see the Passion flower, with its curiously curved pistils; there an iris with its lanceolate leaves; and again bunches of celery with stalks white and tender enough for a fairy's dinner. There are occasional patches of gypsum, tinged of a deep amber colour by

FORMATIVE POWER IN A WATER-DROP



STALACTITES AND STALAGMITES IN THE CAVES BY MARGARET RIVER, WESTERN AUSTRALIA

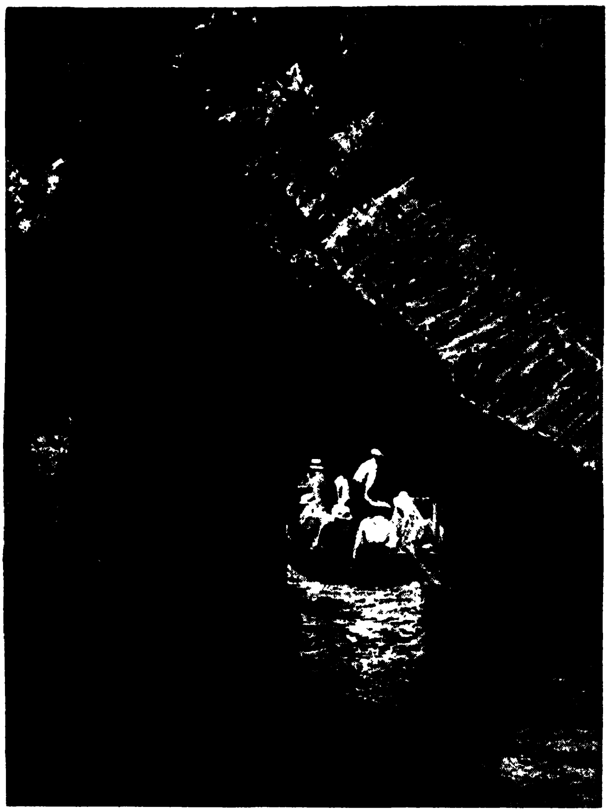
These photographs are published by courtesy of the High Commissioner of Western Australia; others on these pages are by Messrs. Frith, Underwood & Underwood, Ganter, Hains, and Brogi.

the presence of iron. Through the whole length of the avenue there is no cessation of the wondrous work. The pale rock-blooms burst forth everywhere, crowding on each other until the brittle sprays cannot bear their weight, and they fall to the floor. The slow, silent efflorescence still goes on as it has done for ages in that buried tropic." In Mary's Vineyard the stalactites take the form of clusters and clusters of luscious grapes burdening hundreds of dewy boughs. The Star Chamber, again, has myriads of glistening points on its ceiling which look like stars in a dense black sky.

And all this is the effect of aerated water on lime!

Besides these chambers, the Mammoth Cave contains eleven lakes, seven rivers, eight cataracts, and thirty-two abysses. Lake Lethe is a body of water about 400 feet long and 40 feet wide, and the River Styx has about the same dimensions. The Echo River is from 20 to 200 feet wide, and about three-quarters of a mile long. It is called Echo River because of the extraordinary echoes heard along its course. Those produced by agitating the water with a paddle are particularly beautiful.

"The first sound that broke the stillness was like the tinkling of silver bells. Larger and heavier bells then seemed to take up the melody, as the waves sought out the cavities in the rock. And then it appeared as if all chimes of all cathedrals had conspired to raise a tempest of sweet sounds. They then died away to utter silence. We still sat in expectation. Lo, as if from some deep recess which had been hitherto forgotten, came a tone, tender and profound; after which, like gentle memories, were reawakened all the mellow sounds that had gone before, until River Hall rang again."



THE GROTTO AT MORGAT, BRITTANY

It might be thought that the air in these deep recesses must be impure and heavy, but, on the contrary, it is exceptionally pure and exhilarating. Professor Stilliman suggests that it contains an extra amount of oxygen, owing to the amount of nitrogen consumed in the formation of nitre-beds in the cave, but so far this has not been analytically proved. The exhilarating property of the air is so pronounced that tourists always feel especially vigorous and merry underground. At one time, indeed, it was customary to employ delicate men as nitre workers, for it was found that they were quickly restored to good health. Not only is the air pure and exhilarating, but it is, of course, free from germs and of very constant temperature. However hot or cold it may be in the outer air, the temperature of the cave remains constant at about 53 degrees Fahr. to 54 degrees Fahr., the winter mean being the former figure and the summer mean the latter. In view of the purity of the air and the even temperature, it was thought that the cave might make a good sanatorium for consumptives, and in 1843 twelve cottages were built in the cave, and fifteen consumptives took up residence there. But the experiment, probably owing to lack of sunlight, was an utter failure.

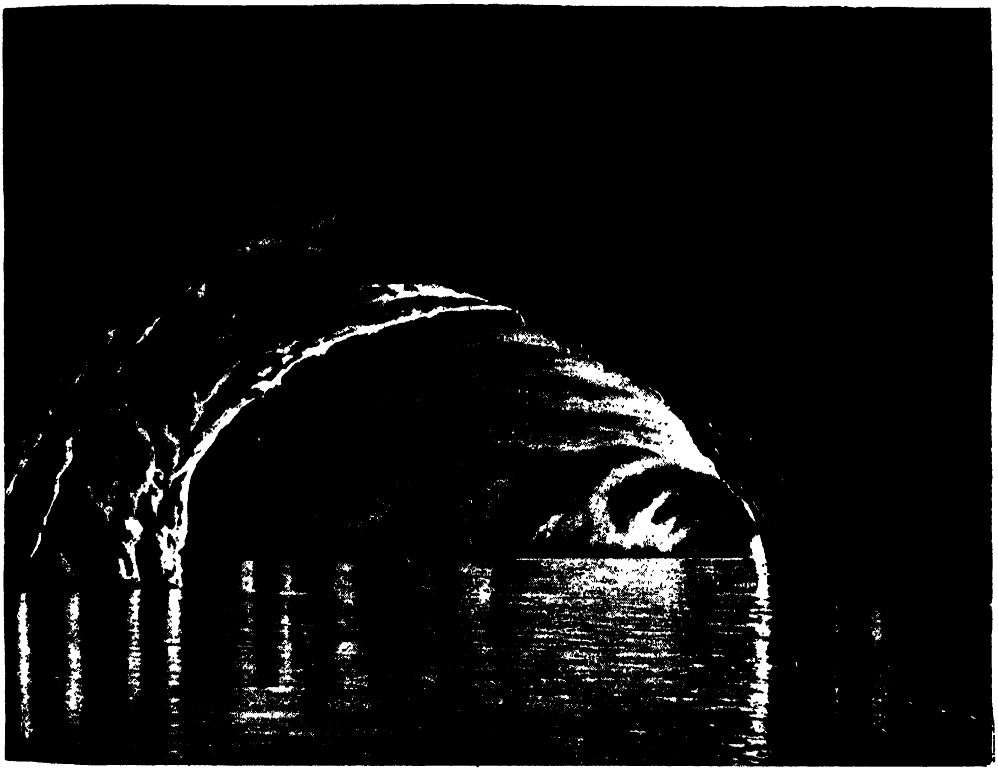
The second largest cave in the world is the Wyandot Cave, in Indiana, and, like the Mammoth Cave, it occurs in a region of limestone rock honeycombed with caverns. It has over twenty-three miles of avenues, and, though not so large as the Mammoth Cave, is in some respects more beautiful.

Its chief marvel is the "Pillar of the Constitution," a column of Oriental alabaster 40 feet high and 75 feet in circumference. The temperature of the cave is the same as the temperature of the Mammoth Cave.

A third enormous cavern is the Cavern of Luray, in Page County, Virginia. This cave probably contains the finest stalactitic display in the world. In the canopy above the "Imperial Spring" no fewer than 40,000 stalactites are to be seen. The Swords of the Titans are 50 feet long and 3 to 8 feet wide, and when struck by the hand give forth sounds like tolling bells. Brand's Cascade is a mass of alabaster like a frozen cataract. "Imagine, if possible," says Hovey, "a great cataract of milk 30 feet wide and 40 feet high, rushing and copious, suddenly caught in mid-air and polished to a wax-like lustre. And beyond it another smaller one, as yellow and golden as liquid amber. And then fancy this whole shining and glorious mass flooded by the dazzling brilliancy of electric lamps, and confess that it must rival the most wonderful scene ever pictured by pencil or pen!"

The temperature of the Luray Cavern is about 54 degrees Fahr., and the air is beautifully pure. The air, indeed, is so pure and so free from dust and germs that the caverns are very difficult to light, since there are no particles in the atmosphere to radiate the light-waves. Some years ago Mr. T. C. Northcott, a Virginian engineer and builder, conceived the idea of utilising this pure, cool air, and, securing a site over the Luray Cavern, he built a sanatorium, and conducted air from the cavern through the rooms, so regulating the supply that the rooms were refilled with fresh air every five minutes. In this way he obtained dustless and germless air. Dr. Guy L. Hunner, of the Johns Hopkins University, who visited the sanatorium in 1901 and 1902, found that there was hardly a particle of dust in the air of the rooms, and, on exposing culture plates, he found that hardly a germ could be discovered. It was, in fact, the purest and clearest atmosphere that can anywhere be found.

There are many other limestone caverns that might be mentioned, but those we have described may be considered as representative of the whole class.



IN THE WONDERFUL BLUE GROTTO AT CAPRI

THE START OF SCIENCE ON A NEW PATH

DR. JENNER INOCULATING HIS OWN SON—THE STATUE BY J. MONTEVERDE AT GENOA

THE DOCTOR'S REVOLUTION

**The Long Past and the Great Future of Medicine :
As It Was, As It Is, and As It Will Be**

A PLEA FOR A NATIONAL HEALTH SERVICE

When we came to the phenomenon of the living world which is called parasitism, we soon found that it opened the way to new ideas of disease, and that the view of disease as largely due to the "struggle for existence" between hosts and parasites led us to new and useful discoveries. We dealt with various diseases, most of them scarcely more than hearsay to us in this country, which depend upon the interplay of lives of two, or often of three, living species, and we saw how this knowledge can be utilised by man in his struggle for life against the other species which tend to use him as their host. Thereafter we saw how a great branch of the "healing art" has been turned into a practical science by the genius of Pasteur and Lister, so that we have a new thing in the world, called Listerian surgery. Now, we have to ask how these modern scientific discoveries affect the art and practice of medicine, apart from the use of the knife. The truth, we shall find, is that medicine is undergoing, at this very moment, the most rapid, important, and remarkable revolution in its age-long history; and the cause of this revolution is the *biological idea of disease* which the nineteenth century discovered, and which we have discussed in previous chapters.

The revolution is only beginning, and we may therefore consider medicine as it was and as it is, for it is still what it has always been, except in rare instances. We shall find one singular invention or discovery, made at the end of the eighteenth century, which really prefigures what is to come; but this, the discovery of vaccination for smallpox, is the remarkable exception, which is only just beginning to find parallels and duplicates in the case of other diseases. Let us therefore briefly survey the history of medical practice until it begins, in our own day, to become what we may properly call a science.

The historians of society tell us that long ago, as nowadays among certain primitive peoples, the priest and the physician took their origin in a single functionary, whom we may call the "medicine man," or "witch doctor." He deals with disease and death on magical principles. But in time, as a little knowledge is acquired, this individual comes to be represented in early societies by two—the primitive priest and the primitive physician. Perhaps the most simple manner of stating the difference between them is that the priest seeks to propitiate the unseen Powers, while the physician seeks to attack them. Hence there is always a tendency, which is quite familiar today, for the priest to look upon the physician, his investigations, and his processes, as impious. The "decrees of Providence" may be inscrutable, but they must be accepted. The priestly intercession is right, but the physician's attack, say, by anæsthetics or by vaccination, upon the "divine dispensations" is impious. Hence an age-long quarrel which is not yet ended.

The primitive physician, we said, tries to attack and defeat the causes of disease and death. The all-important question, then, is the mode in which he figures those causes to himself. In so far as his ideas are right, his attack will be successful, and vice versâ. We may briefly say that the modern age, and the possibility of scientific medicine, depend upon the slow but certain disappearance of the idea of the causation of disease which the primitive priest inherited from his precursor, the priest-physician or medicine man. That idea, in a word, was demonological. Disease was due, above all, to the influence of malign spirits, or demons. "He hath a devil," was the simple explanation of many maladies, and when we say that a man behaved like one "possessed" we quote the same idea, that a demon or

devil may come and take possession of a man's body, with disastrous consequences. This is a view of disease which is clearly derived from the primitive conception of all phenomena as caused by the agency of unseen beings, friendly or hostile to man—perhaps the spirits of the dead, or creatures of orders altogether different from man.

The Doctoring that Tried to Make the Body Disagreeable to Invading Demons

How, then, must the physician, as a champion of man against these other creatures, try to deal with them? One method will surely be to make the patient's body *inhospitable*. We may observe that this is the very idea which will prevail in the medicine of the near future; the only difference lies in our ideas of the kind of invader whom we seek to keep or drive away. A simple argument of the past was to the effect that the patient's body might be made uninhabitable to the unwelcome guest—as now we are trying to make it inhospitable to the unwelcome parasite—by the administration of drugs that had an offensive taste or odour or both.

We might go through the pages of the current edition of the British or any other Pharmacopœia, and mark large numbers of drugs which owe their presence therein—little though modern practitioners may remember the fact—to their nauseous taste and odour, and to the demonological view of disease. The hope was that, when the patient's body was saturated with such evil-smelling substances as, say, asafœtida, the demon that possessed it would be forced to terminate its tenancy, and the patient would be relieved. Such views especially applied to those forms of nervous disease where it does almost look as if some other being than the patient had obtained control of him, as in many forms of insanity and epilepsy, and in the delirium of many fevers. In the ninth chapter of St. Mark a vivid account is given, in demonological language, of a case which we should now call epilepsy, where the spirit is described as throwing the patient whom it possessed into the fire.

The Doctoring that Tried to Modify the "Humours of the Body"

Naturally, there were many minds, in the course of the centuries, who sought more rational ideas of disease than this. Often the reasonable idea occurred to them that disease was due to disordered action of the chemistry of the body. Certain fluids or "humours" were recognised, the right or wrong condition of which was supposed to determine health and disease, and this "humoral" theory of disease prevailed for a long time. We see an instance of it in the theory of smallpox which was entertained by so great a physician as Thomas Sydenham in the eighteenth century, when he said that the disease, then so common that he thought it must be a natural process, arose "from a desire the blood hath to change its state." That was far enough from the truth, but we well know that the "humoral" theory of disease has an essential truth in it. Accordingly, we may try to modify the humours of the body in such ways as will preserve health and avert disease. This opens the way to a new class of medicinal substances, as distinguished from all the foul and disgusting messes which were designed for the discomfort of hypothetical demons. Why should we not directly alter the composition of the blood, by rubbing certain fluids into a scratch, or injecting them through a hollow needle, so that it will thereafter resist disease?

Thus we reach the idea of inoculation, which has, in fact, been occasionally practised by mankind for a very long time. It specially concerns us here, however, in regard to one disease, the conquest of which is the great outstanding triumph of the period of medical science which is now passing away.

The Practice of Inoculation with Disease to Secure Immunity from It

It seems that in various parts of Asia the practice of inoculation for smallpox is very old—in Hindostan, they say, older than the Christian era. A little of the material from a pustule upon the skin of a smallpox patient is transferred to a small wound, purposely made in the skin of the person to be inoculated, and this person thereupon manifests the disease, but usually in a mild form. The advantage of this proceeding is that, after recovery, the patient is *immune* to the disease.

We owe to a very remarkable woman, Lady Mary Wortley Montagu, the introduction of inoculation of smallpox into this country. She had her own boy successfully inoculated, and in 1722 the Princess of Wales had two of her children inoculated. In 1754 the Royal College of Physicians publicly described the method as "highly beneficial to the human race." Though many deaths occurred, so prevalent was smallpox, and so much feared that people crowded to undergo the new treatment. Unfortunately, there was nothing done to prevent the spread of the disease from inoculated persons. They should have

been placed in quarantine, but, instead, they were allowed to infect other people; so that in Boston, for instance, "seven hundred and sixty persons died during the first three months of inoculation, and the town became 'a mere hospital.'" At this time the prevalence of smallpox was almost incredible. In one year in Russia, two million died during an epidemic. Poor Russia still knows what smallpox means, though we have forgotten.

How our Countrymen Treat Life-Giving Heroes Compared with Heroes of War

But in 1749 there was born in Gloucestershire the child who was to conquer the disease. His name was Edward Jenner. A statue to him stands in Kensington Gardens. Herbert Spencer gives us the following observations, supposed to be made upon the English people by "an observer living in the far future":

"Their distribution of monumental honours was, indeed, in all respects remarkable. To a physician named Jenner, who, by a mode of mitigating the ravages of a horrible disease, was said to have rescued many thousands from death, they erected a memorial statue in one of their chief public places. After some years, however, repenting them of giving to this statue so conspicuous a position, they banished it to a far corner of one of their suburban gardens frequented chiefly by children and nursemaids; and in its place they erected a statue to a great leader of their fighters—one Napier, who had helped them to conquer and keep down certain weaker races. The reporter does not tell us whether this last had been instrumental in destroying as many lives as the first had saved; but he remarks: 'I could not cease wondering at this strange substitution among a people who professed a religion of peace.'"

The Reception of Vaccination by the Medical and Clerical Professions

The young Jenner studied medicine in London under John Hunter, the great anatomist who founded the Hunterian Museum of the Royal College of Surgeons, the finest museum of its kind in the world. The great teacher had a worthy pupil. One day there came to Jenner a young countrywoman, to consult him. Smallpox happened to be mentioned in her presence, and she said: "I cannot take that disease, for I have had the cowpox." Jenner was greatly struck by her observation, and soon began making experiments. Cowpox, or vaccinia (Latin, *vacca*, a cow), is an unimportant disease of the udders of cows, which may sometimes be communicated to the hands of those who milk them. In 1796, after numerous experiments on his own infant son, Jenner vaccinated a boy by introducing matter from a sore on the hands of a dairymaid. A few weeks later, the vaccination having taken, the boy was inoculated with smallpox, and would not "take." Jenner sent an account of the case to the Royal Society—*which returned it!*

But this was too precious a discovery to be suppressed. Let us remember that at this time one child in five died of the disease before reaching adult life, and that very few of the survivors escaped without disfigurement of the face, while large numbers lost their sight. The enemies of vaccination were numerous but unsuccessful. They especially argued that the result of vaccination was to produce a cow or ox-like appearance of the face; that the vaccinated coughed like cows or bellowed like bulls, and grew hairy over the body. One doctor put the case in a nutshell: "Smallpox is a visitation from God, but the cowpox is produced by presumptuous man; the former was what Heaven ordained, the latter is, perhaps, a daring violation of our holy religion." But even this could not arrest so beneficent a discovery for mankind at large.

The Epoch-Making Triumph of Jenner in Face of All Opposition

Jenner became one of the most famous of living men. The King of Spain, the Emperor of Austria, and Napoleon released prisoners at his request, and a certificate with his name was a passport in any civilised country in the world. Nowadays we have no idea what his discovery meant, simply because its work has been so thoroughly done. In Germany, where vaccination and revaccination are thoroughly carried out, the disease can no longer be said to exist. From 1874 to 1896 there was only one death from it in the whole German Army. "During the Franco-Prussian War Prussia had 216,426 of her soldiers vaccinated, while France had only 40,000. In the French Army, accordingly, 23,469 soldiers died of smallpox, while in the German Army only 316 died. In the epidemic at Sheffield in 1887–88, among 68,236 vaccinated children there were 353 attacks and six deaths, while among 2259 unvaccinated children there were 228 attacks and 100 deaths."

A most important change has become complete within recent times. The arm-to-arm vaccination of the past has been superseded by vaccination with calf lymph,

which can nowadays be prepared and preserved under very exact and safe conditions. The importance of abolishing arm-to-arm vaccination is very real. Without anyone being aware of the fact, the child from whose arm the vaccine was taken might be suffering from the infection of, say, syphilis, and thus the second child might have this infection conveyed to it with the vaccinia. Such an accident is too horrible to contemplate, and even a single case of the kind might well create thousands of anti-vaccinators. But such risks cease to exist if we abolish arm-to-arm vaccination and substitute the use of "glycerinated calf lymph," for the calf does not suffer from syphilis, and the lymph obtained from it can be so treated that no infection but that of vaccinia can be communicated to the child.

The Ultra-Microscopic Parasite that Causes Both Cowpox and Smallpox

But how are we to explain this strange fact that the attack of cowpox should prevent one from having smallpox? Undoubtedly the two diseases are one. Cowpox is due to a living organism which is the same as that producing smallpox, but is modified in behaviour and in virulence by its existence in the body of the cow, which is a more resistant animal than man. Naturally, we ask whether the parasite of smallpox is a bacillus or a trypanosome, or what. It can be neither, nor can it belong, we are practically certain, to any of the groups of living things which ordinary microscopic methods will enable us to detect. It must be ultra-microscopic, and whether animal or vegetable hardly matters, for the distinction cannot be said to exist in such a humble grade of life. There may be considerable resemblances between the parasite of smallpox and what we are beginning to regard as the parasite of yellow-fever, an ultra-microscopic form of life about which no more can be asserted than its living nature, its minuteness, and its consequences. If the next decade marks half the advance of the past decade, we shall soon be able to be more definite. Meanwhile, no epidemiologist doubts that smallpox, or variola, to use the technical name, and cowpox, or vaccinia, are modifications of one and the same disease, due to two forms of one and the same parasite.

The Object of Vaccinators—to Exhaust the Nutriment on which Smallpox would Feed

How, then, does an attack of the one disease protect from the other? This is really no more or less than the simpler question, How does one attack of smallpox itself protect from others. Vaccinia simply a modified smallpox, and it protec just as the inoculation of smallpox pr tected, when it did not kill. The patie becomes immune, in greater or less degre and for a shorter or longer period. H immunity is *acquired*, not native, like, sa the immunity of the calf to syphilis. H was born susceptible, and he acquires a immunity which, so far as we know, personal to himself, and cannot be hande on by him to his offspring. What has ha pened? Nay, we may ask what must b the same question in another form. Wh does anyone recover from smallpox or an other infectious disease? The parasite multiply and multiply, the patient becom worse and worse, and then he begins to ge better, and is, in many cases, immune fo the future. Pasteur's own view was tha every parasite has a special form of nutr ment which it finds in the body, and tha when this nutriment is exhausted the para sites must die from starvation, as invadin armies of other kinds have done before now We know now, however, that this simpl theory of Pasteur's does not explain th facts. We shall return to this problen when we deal with the work of two grea living successors of Jenner and Pasteur.

The Success of the Anti-Toxin Treatment of Diphtheria

Vaccination against smallpox stands ou as the one great triumph of medicine befor Pasteur, if we except the quinine treatmen of malaria, and after about a century w come to another achievement, which als has as little to do with the traditional prac tice and ideas of medicine as had Jenner' invention. The achievement in question i the anti-toxin treatment of diphtheria, whicl we owe to France and Germany and Japan Until the most recent days it has stoo alone, as vaccination against smallpox ha stood alone. But it also depends upon th *acquirement of immunity* by some means o other, and it may help us towards a bette theory of that acquirement than Pasteur's.

Diphtheria is a well-known and long deadly disease due to a certain bacillus which was discovered by Klebs in 1883. That discovery, which we owe, of course, to the work of Pasteur, marked the beginning of the end of this disease. Seven years later the celebrated Japanese bacteriologist, Kitasato, found that an animal could be protected from diphtheria by injection of some of the blood-serum of another animal which had recovered from the disease. Here, evidently, is a fact which,

in the first place, does not tally with Pasteur's theory of acquired immunity. The animal which has acquired immunity is not merely one which contains nothing fit to nourish the diphtheria bacillus. Its blood evidently contains some positive substance, which either *kills* diphtheria bacilli or renders them harmless, and this it can do in and for the body of a second animal.

A quite simple theory—at least, simple in outline — will explain the facts. The diphtheria bacilli, multiplying in the throat of the patient, produce a poison, or toxin, which we may call the diphtheria toxin. This is the substance which causes the grave symptoms of the disease, and may produce death by its action on the heart and otherwise. But, somehow, somewhere, the body replies by the production of another substance, which neutralises the toxin so that it can do no more harm. This second substance is poured into the blood from the sources of its manufacture (as to which we may still dispute), and so can be obtained from the blood of an animal which has suffered from diphtheria. It is possible to mix the toxin and the anti-toxin outside the body, and then, by injecting the mixture, to show that it is inert; but the toxin alone would have produced grave consequences.

THE APOTHECARY OF OLDEN TIMES
From the painting by H. Stacy Marks, R.A.

The theory needs elaboration, especially as to the source of anti-toxin, but the practice is very simple. The diphtheria bacillus is cultivated by millions in a bouillon or beef tea which suits it, and then the mixture is filtered. Thus we have a fluid which contains no microbes, but is crammed with their toxin. A few drops of it may kill an animal as large as a horse, and so we have absolute demonstration of the production of a tangible poison by certain microbes, even when they are grown in a not-living medium. There being no microbes in the filtered fluid, we can give exact doses of it, knowing that they will not increase inside the body of the animal we dose, as they would if the microbes were present. We thus subject a horse to graduated doses, finding that ever larger quantities of the toxin can be given at a time without injuring it. The horse, by the way, suffers no injury or discomfort, and the horses which are kept for this purpose probably have the most comfortable lives of any horses anywhere. The injection and the subsequent processes neither hurt or weaken the animal. If we now bleed the horse to a small degree—a process which it will not even interrupt its feeding to endure—and allow the blood to coagulate, we shall have a clearish fluid which, in fact, is crammed with diphtheria anti-toxin. This fluid is the anti-diphtheritic serum which has saved scores of thousands of lives in the course of the last fifteen or twenty years.

It contains no microbes, but only a special chemical compound which exactly neutralises the toxin of diphtheria. We might hope to make this anti-toxin by chemical processes invented in the laboratory, and that may yet be done, but the best chemists would be the first to admit that at present we have no idea of the first step in such a

process. There is only one known way of obtaining this unique remedy, and that is to invoke the activity of the living cells of an animal which is susceptible to the toxin. It might be thought that the anti-toxin is made from the toxin, by some comparatively small change in its structure, and such a process may occur. But that cannot cover all the facts. The production of anti-toxin is out of all proportion to the toxin which elicits it. The body cells seem to go on elaborating this substance in far greater quantity than is really needed. That is why the blood of the horse, or of any human patient who is not killed, contains an enormous excess of the anti-toxin.

If now we inject a small quantity of the horse's serum under the skin of a child who is dying of diphtheria, its symptoms will almost always disappear, and it will recover. No other substance in the world has this property. No antiseptics, applied to the throat, are effective; quinine is useless, alcohol is worse than useless, and no doctor had hitherto saved a case of diphtheria except by making a surgical passage for respiration when the diphtheritic membrane was closing the larynx. The anti-toxin has changed all that. In the Metropolitan Asylums Board Hospitals anti-toxin was first used in 1895, and the case-mortality has steadily fallen ever since.

LADY MARY WORTLEY MONTAGU

At the Brook Hospital in New York the mortality of cases treated on the first day was 0·0 per cent; on the second day, 4·1; on the third day, 11·9; the fourth day, 12·4; and thereafter, 16·6. An American investigation on a large scale gave the following percentages for the first five days: 4·9, 7·4, 8·8, 20·7, 35·3. The question is simply how soon the treatment can be applied. If we wait until the toxin has had time to cause degeneration of the nerves of the heart, perhaps, then the child may die in consequence of that degeneration, even though the use of anti-toxin prevents any further damage being done. But cases treated on the first day practically never die nowadays. The disease is conquered.

While we recognise this great and glorious triumph of recent medicine, let us add that best of all would be to prevent the disease from spreading at all. At periods since the discovery of anti-toxin the number of *cases of diphtheria* has sometimes increased, and it has therefore been argued, by Mr. Stephen Coleridge and others, that the anti-toxin is a failure. What the anti-toxin does, however, is to reduce to almost negligible proportions the death-rate among those attacked.

Approximately contemporaneous with this discovery came another, based on quite different principles, which also marks the beginning of a new era, and prepares us to consider the medicine of the future. There is a gland in the neck, called the thyroid, the function of which was long unknown. It has no ducts, and appears to produce no secretion. Experiments in the lower animals showed, however, that the loss of this gland produced very remarkable and disastrous symptoms, which could be relieved by the administration of thyroid substance obtained from some other animal. In cretinism, or cretinous idiocy, the gland is not properly developed. In a disease of the adult called myxœdema the gland is found to have undergone an enlargement, indeed, but one that depends upon a degeneration of the functional parts of the organ. Hence the experiment was tried of administering thyroid substance in cases of cretinism and myxœdema, with the most magnificent results. There is now no question that the symptoms of these diseases depend upon lack of the thyroid secretion, and may accordingly be relieved if that lack is made good from without.

In vaccination against smallpox, the anti-toxin treatment of diphtheria, and the thyroid treatment of cretinism and myxœdema we have three great discoveries which stand out from the medical science of the past, and are no less conspicuous in the present. In the medicine of the near future, which we are shortly to discuss, the principles illustrated by these three discoveries will show their full worth. Meanwhile, let us survey the science and practice of medicine as they exist today, looking at them from the biological standpoint which has proved itself to be so valuable.

On the whole, the verdict is one of condemnation. Methods, principles, details

are alike wrong. In the first place, by far the greater part of all medical practice—we are not here dealing with surgery, which is a very different matter—consists of the giving of drugs for the relief of symptoms. Now, everyone who has a painful or distressing symptom may be glad to have it relieved, but such relief is of no more than momentary usefulness, and it does nothing towards the control of disease as a whole. Most doctors have to spend most of their lives in prescribing sedatives for the relief of coughs, while the microbes responsible for the bronchitis, the "cold," the influenza, the pneumonia, or the tuberculosis, are allowed to pass from the patient to others. To this kind of medical practice there can be no end, for no real headway is being made against the causes of the disease in question. That is the first indictment, then. Most of the medical practice of our time consists of the mere shutting down of symptoms, or of the futile attempt to do so, by means of drugs nine-tenths of which had better never have been discovered.

EDWARD JENNER
The statue that was removed from Trafalgar Square to Kensington Gardens

The theory of medical practice today, as ever in the past, has been that the physician is to cure when illness appears. Now, the total number of illnesses in which he can cure is tiny. We have noted in this chapter the use of the diphtheria anti-toxin and of thyroid extract. If to those two drugs of the new order we add quinine, iron, mercury, from the welter of the pharmacopœias, the tale is practically complete. For the rest, the physician *does not cure.*

If now we consider such a disease as yellow fever, a new consideration begins to appear. Here is a disease which no physician can cure. He may slightly alleviate symptoms, but it is most probable that the patient will die, and no patient who ever recovered was cured by his physician. On the other hand, the disease may be totally abolished in places where for centuries it has been responsible for a quarter of the death-rate. Similar is the case of leprosy, and of many other diseases. The question therefore arises whether the whole theory and practice of the medical sciences ought not to be reconstituted upon a basis of prevention instead of cure.

We commonly repeat that prevention is better than cure, but we do not realise the most cogent reason why that is so. Above all, the prevention of leprosy or yellow fever or plague is better than cure, because it is possible, while cure is impossible. We admit that curative medicine has triumphs to record. We have duly noted diphtheria anti-toxin and thyroid extract, and we may add the "606" of Professor Ehrlich. But these, valuable though they be, are no more than the meagre exceptions to the rule, which is that doctors do not cure their patients. If and when the patients recover, they cure themselves, except in such rare and glorious exceptions as the use of the diphtheria anti-toxin, where the blood of the horse, long the friend of man, now performs this unique and incomparable service for him. On the other hand, our new knowledge of the causes of many diseases which we cannot cure, such as yellow fever, plague, and typhus, gives us the power to prevent altogether, if we choose. Would it not be better to organise the medical

profession so that it may do what it can do, instead of continuing to pay its members for trying to do what they cannot do ?

Yet another consideration. From the unexamined point of view, disease is an individual matter. I am ill, and I want to be well, so I will call in a doctor; but if my neighbour is ill, that is his affair—let him call in his doctor. This view may be adequate for certain kinds of disease, such as, say, gout or dyspepsia, or for such a disaster as a broken bone. But if we take the problem of disease as a whole we find that, though its ultimate importance depends upon the injury it does to individuals, it is not really a problem for the individual.

Why the Health of Our Neighbour is Our Own Business

The overwhelming proportion of all disease is parasitic; it depends upon a struggle for existence between living species, and man is one of the species concerned. This alters the complexion of the problem. I may not care a straw for my neighbour, and may be indifferent to the sociological teaching that he and I are mutually dependent; but it matters very much to me that he has pneumonic plague, when I learn that the sputum in that disease conveys infection, and that the death-rate is 100 per cent. His illness becomes my business; it may be quite worth my while to send for and even to pay his doctor.

Now, that is simply a parable of the disease problem as we now see it. A few decades ago consumption was thought to be a hereditary degeneration of the lungs, and no one else's consumption need worry me. Now we know that the disease is an infection, and that every consumptive who has an expectoration is sowing the seeds of death for others. The individualist view of disease breaks down again. What is true of consumption is true of *all* the familiar diseases of the respiratory organs, such as influenza; it is true not merely of notoriously infectious diseases of childhood such as measles, but also, as we have recently learnt, of infantile paralysis.

The Power of Man to Sweep the Parasite off the Earth

The problem of disease is, above all, one of parasitism; and if we are to justify the assertion of our great master Pasteur that " it is in the power of man to make all parasitic diseases disappear from the earth," we must reorganise the defence of our species against its enemies on an appropriate basis.

The beginnings of the new order of things already exist, in the form of the Medical Officer of Health. Here we have a medical man who is asked to spend his life not upon the mainly impossible, but upon the possible. His business is to prevent disease. When plague appears he must prevent its spread, as on many recent occasions at our great ports. When typhoid appears he must trace its source, and deal with it. The less disease there is, the lighter is his work and the better is he paid in proportion to it. In every case the medical officer of health should have special qualifications in the new theory of disease; in every case his time should be wholly devoted to this work; and in every case his tenure of office should not be dependent upon the favour in which he is held by local individuals who may be personally responsible for the insanitary premises which it is his duty to condemn. The medical officer of health should be an accredited servant of society as a whole, and responsible to no section of it.

A Policy of Life and Death for a Political Party

For these reasons it is necessary to have a Ministry of Health, which shall rank in national importance with any other department of State. For such a Ministry of Health Sir Clifford Allbutt, Regius Professor of Medicine in the University of Cambridge, has long pleaded, and its establishment cannot be very much longer delayed. Either of the political parties might do worse than consider this question. Many years ago the Conservative Party, under the leadership of a man of genius who could boast racial affinity to Moses, advanced a programme which, if carried out, would ultimately have placed our methods of national health upon a level with those which Moses instituted more than three thousand years ago, and which have largely helped to maintain the Jewish race ever since. In 1872, now forty years ago, Lord Beaconsfield laid it down, in a speech at the Crystal Palace, that " the health of the people is the most important question for a statesman." " Sanitas, sanitas, omnia sanitas " was his motto, and a conspicuous opponent described it as a " policy of sewage." But it is, as he replied, a policy of life and death, and to that policy the modern State must come. An initial step will be the creation of a Ministry of Health.

Further is required a National Health Service, which would necessarily include the greater part of the medical profession.

There would always be room and need for the private practitioner whom those could consult who pleased. But the greater part of the profession would and will be composed of members of a National Health Service, existing primarily for the prevention of disease, and looking upon the problem of disease as a biological and national one, only to be dealt with as a whole, without reference to the status or pocket of individual victims. The arguments in favour of such a National Health Service have been magnificently and cogently stated by a distinguished authority, Professor Benjamin Moore, of Liverpool, in his recent little volume, "The Dawn of the Health Age." It should be read by every serious student of this subject, and already it has had an enormous influence upon public opinion. These arguments are again presented by a leading surgeon, Mr. C. J. Bond, of Leicester, in the essay which he contributes to a recent volume called "The Great State."

How soon will reform come? A disconcerting comment is furnished by a believer in democracy, Mr. James Bryce, in his recent discussion of the Panama Canal. Here we have demonstrated the most complete and successful abolition of disease in history, at any rate since Moses. But to what do we owe the strenuous regulations, the complete prohibition of alcohol, and so forth, that made the canal possible? Not to a democratic form of rule, but to a practical military autocracy, a despotism for the saving of life. For similar success here, we shall need a new kind of democracy, educated and disciplined, whose coming may these pages serve!

A TWENTIETH CENTURY WITCH-DOCTOR AND HER CLIENTS IN ARCTIC SIBERIA

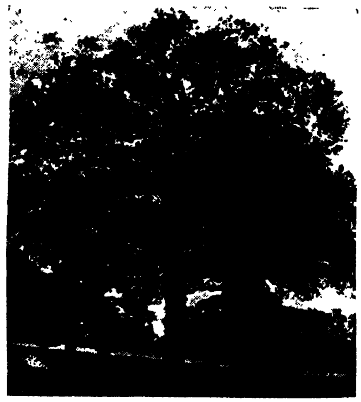
IDENTIFICATION OF TREES BY SHAPE

THE MAPLE

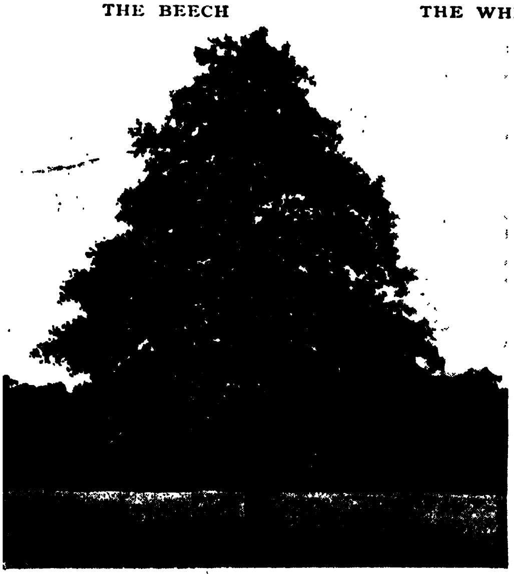
THE ASH

THE BEECH

THE WHITE POPLAR



THE OAK



THE ALDER

THE ELM

TREES AS A SPECTACLE

The Massing of Branches and Leaves so that Trees May Be Identified by Their General Effect

THE SECRET OF AUTUMNAL COLOURING

READERS who have followed us throughout the discussion of the various principles which underlie the physiology of plants ought, by this time, to have a fairly complete grasp of the manner in which a plant lives its life. Especially have we studied some of the more lowly forms of plant life, because in them is to be found a greater simplicity of structure and function, which, therefore, lends itself to preliminary study. There remains for our consideration the group of plants differentiated from others in the popular mind mainly in virtue of their great bulk and size, the plants which we generally speak of as trees.

There is no occasion for us to attempt to draw a very hard and fast line between plants which are trees and those which are shrubs, or semi-shrubs, or even perennial herbs. Nature herself draws no such definite lines of demarcation, though it is convenient for purposes of discussion and classification to have a rough definition of what such terms mean. For our purpose here it will be sufficient if we regard a tree as a plant that possesses an erect trunk, with more or less spreading branches, both the trunk and the branches having a woody composition and structure. Branches and stem are, of course, *perennial*. It is this characteristic of woodiness, taken together with the size and bulk usually associated with it, that settles whether a plant is to be regarded as a tree or not.

Manifestly, it is impossible within the scope of a few pages to attempt to deal adequately with all the aspects of tree life. Whole books might be, and, indeed, are, devoted to them from different points of view. Almost every one is interested in, and takes notice of, trees, because they play such an important part in the lives of human beings as prominent features in the formation of human environment. The lover of Nature, whether he be a painter of pictures, a photographic artist, a gardener, or the man in the street, never ceases to interest himself in the varying appearance of the trees around him as the seasons succeed each other. The services trees render to mankind in general, to some of which we shall refer later, doubtless have caused them to be by far the best known of all forms of plant life; and so it is that in every country the different species of trees have received special names from the earliest times, each country having its own favourites extolled in the national song and literature, and playing their parts in olden days in religious ceremonies. Indeed, in all countries, trees are bound up with the national habit of life in a very intimate way. Even the great majority of people who know nothing of botany can distinguish readily the most important and best-known trees of their own land. How can they do this? The answer to that question brings us to our first point—namely, that every tree has its own special characteristic features and appearance, just as much as has every human individual, and these distinctive features, by long association, become so familiar to the people who see them that they have no difficulty in recognising, even at a distance, trees of a similar *habit*. It is this *habit* of trees which makes it possible for the artist to give an accurate impression of the species of a tree without representing its actual details of structure. We may, therefore, pay a little attention to what constitutes the *habit* of a tree.

Lying at the very foundation of this tree *habit* is the relationship which exists in the arrangements of the leaves and branches, and their reference to each other and other parts. In every tree it will be found that the arrangement of the buds depends upon the exact position of the foliage leaves, and

this in turn, of course, governs the manner in which the small side branches come off from the larger branches. The appearance produced by these several factors largely determines the hab:t, or manner of growth, of the tree. These leaf and bud arrangements are very complicated in their detailed study, and are capable of being reduced to mathematical formulæ and diagrammatic representation. Into these, however, we need not enter here; they can be studied in botanical text-books. It will be sufficient to say that branches, like leaves, have definite geometrical relations, and that these are largely responsible for the specific appearance each tree constantly shows.

Branches, like leaves, are either arranged along a spiral line, or else decussate, or else they are whorled. Thus, in the maple and the ash we observe the decussating branches. The elms, limes, and alders have their leaves on what botanists term the one-half and one-third system; while beeches, oaks, and poplars exhibit the two-fifths and three-eighths arrangement. It is these mathematical variations of leaf and branch relationships which contribute so much to the *habit* of the tree. This definite arrangement of branching in different species enables the observer to recognise a tree at a distance, even in the depths of winter, when the foliage is absent; and, of course, during the time of leaves it also gives an equally definite arrangement to the leafy crown of foliage. Hence the painter is able to reproduce on his canvas a more or less accurate representation of the *habit* of a tree, even though he does not represent in detail either branch or leaf.

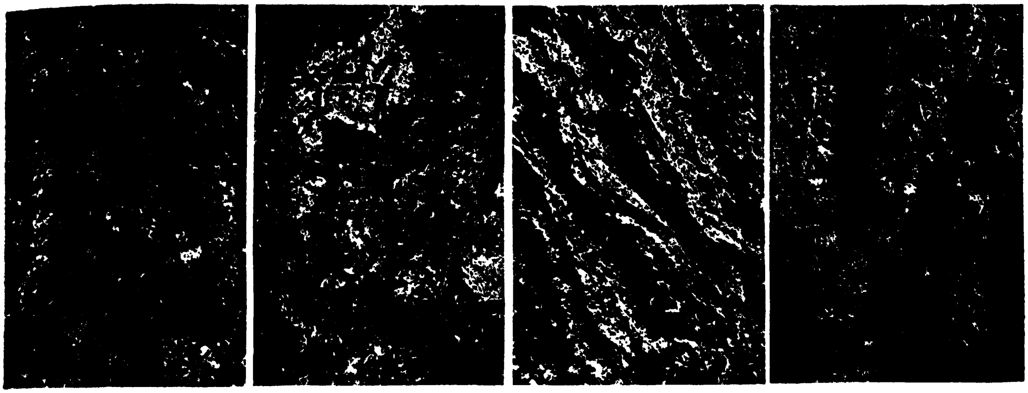
EPIDERM OF YOUNG AND PERIDERM OF OLD OAK

The shape of each leaf has a definite relationship to that of the whole tree. Those trees whose branches produce long needle-shaped or pointed leaves have, of course, far less weight to carry than those whose branches produce outspreading, flat leaves with much surface. The former tree, therefore, tends to shoot up to a greater height, while the latter, bearing an immensely greater weight of leaf material, tends to spread laterally. This distinction is seen in trees all over the world. Compare, for example, the striking differences in the *habit* seen in the giantic eucalyptus of Australia with the *habit* of the British oak. The latter, our most venerable British tree, having an immense leaf area to support, naturally produces a correspondingly thick trunk and sturdy branches; while trees like the eucalyptus and our own fir-trees, which bear linear leaves or else needlelike leaves, require no such massive framework.

Another point to be noted is the general *habit*, or *configuration*, of a tree in connection with the penetration of light to the leaves produced in the lowest branches. Obviously, the greater the amount of foliage towards the top of the tree, the greater will be the difficulty experienced by the lowest leaves in getting light. One of two things must happen. Either the branches below must grow laterally, so far that their leaves may project into the sunlight, or these branches will wither and die, finally breaking off. Those which can shoot out far enough generally curl upwards at their extremities, as may be seen in the chestnut and the ash. A characteristic feature in all tree *habits* is the trunk, or stem. Indeed, this alone is often sufficient for purposes of recognition.

The greater the weight of branch and leaf which has to be borne, the stronger and stouter must a trunk or stem, of necessity, be; and so we find that these two factors have a definite relationship to each other. The trunk increases in thickness year by year by the formation of new wood. Each annual deposit, which is arranged around the central core, is known as an *annual ring*, and the estimation of these annual rings affords a means of ascertaining the age of any tree that has been cut down. As long as the stem is growing chiefly in

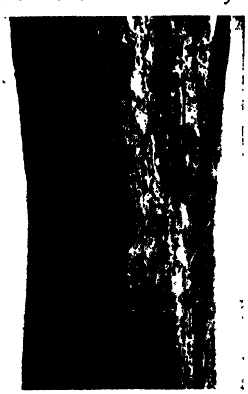
height, it is covered by a simple skin, or epidermis, but later on it assumes a more permanent character, and has a corky element added to it. It is then called the *periderm.* The significance of this addition of cork to the trunk is that it is waterproof and almost air-tight, so that the inner structures, which conduct the sap from one part of the tree to another, are adequately protected from seasonal and climatic changes.



FOUR STAGES IN THE DEVELOPMENT OF THE FISSURED BARK OF AN OAK

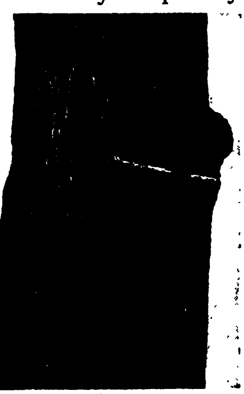
The growth of this periderm is continuous with that of the trunk, stretching after every annual ring is deposited, and as it gets thicker becoming split up into cracks and lumps. New bark is formed to fill up the cracks. The bark itself is just as characteristic of most trees as are the leaves or the branches, and it is found to differ immensely in its texture and colour as well as in its superficial arrangement. We have *scaly* barks, which come off every year in little plates, as seen in the almond willows and some eucalypti ; *membraneous* barks, which strip off like ribbon, as in the common birch ; *fibrous* bark, such as that of the vine ; and, lastly, the *fissured* barks of the ash, the oak, the lime, and many thickly foliaged trees. In these the bark splits into ridges and patches in an irregular or zig-zag manner, and it is in such barks as these that we find growing the mosses and lichens.

SCALY BARK OF WILLOW



MEMBRANEOUS BARK OF BIRCH

FIBROUS BARK OF HONEYSUCKLE



FISSURED BARK OF OAK

It may be noted in passing that pictures of trees, which otherwise depict accurately the *habit* of the species in question, are very frequently at fault in the matter of the bark. Its colour is just as characteristic as that of the leaf. We have said that trees are the best known plants of all, mainly, perhaps, from the simple fact that they are the largest ; and although one cannot give exact figures as to the height and age to which every species of tree may attain, nevertheless it is as true of trees as it is of animals, that each species has its average limit. Figures based upon historic records or local legends are very frequently exaggerated, and some of these given must be taken with some slight reservation.

" The celebrated baobab (says Kerner), was reckoned by Adanson, on the ground of the thickness of the annual growth, to be about 5000 years old, but whether a

miscalculation has not crept in must remain uncertain. The age of the celebrated dragon-tree of Orotava has even been estimated at 6000 years; the plane of Bujukdere, on the Bosphorus, at 4000; and the so-called Mexican cedar was estimated by Humboldt at 4000 years. I would not like to stand security for these numbers either. On the other hand, the following extreme limits of age are calculated with fair accuracy. For the cypress, 3000 years; the yew, 3000; the chestnut, 2000; the oak, 2000; the cedar of Lebanon, 2000; the spruce fir, 1200; the broad-leaved lime, 1000; the Arolla pine, 500–700; the larch, 600; the Scotch pine, 570; the abele, 500; the beech, 300; the ash, 200–300; the hornbeam, 150 years."

As regards the height to which certain species of trees may attain, it is interesting to note that the highest eucalyptus, that giant of the world of trees, grows a stem which, when placed beside St. Paul's Cathedral, would actually reach about sixty feet higher than the cross, being only a little lower than the top of Cologne Cathedral. There have been stems of trees whose certified diameter was some sixty feet, and whose stems reached an altitude of 346 feet, or thereabouts, above the ground.

THE DRAGON-TREE OF OROTAVA, WHICH LIVED FOR SIX THOUSAND YEARS

Passing now from the consideration of these structural features which contribute to the *habit* of any given species of tree, we may pay a little attention to what may be regarded by many as the chief æsthetic value from, or attraction possessed by, them—namely, the production of the marvellous variety of autumnal tints which delight the eye of all lovers of Nature. For, after all, it is the autumn coloration of the foliage of trees which is their chief attraction to the eye, rather than their flowers. Most large trees produce flowers in immense numbers, but the inflorescence is only a small one. Some of the flower leaves are of the same green colour as the rest of the foliage, which makes them correspondingly inconspicuous, while others, on the other hand, produce such masses of flowers that the whole tree may give the appearance of one immense bouquet. In this latter case we find that the flowers, or blossoms, are produced before the green foliage has made its full appearance. The best examples of it are seen in some of our fruit-trees, such as the cherry and the almond, whose branches in the early spring, before the leaves have appeared, are simply a mass of flowers. But, apart from trees of this character, the most brilliant colour schemes are associated with autumn foliage, and we must pay a little attention to this while we are dealing with trees.

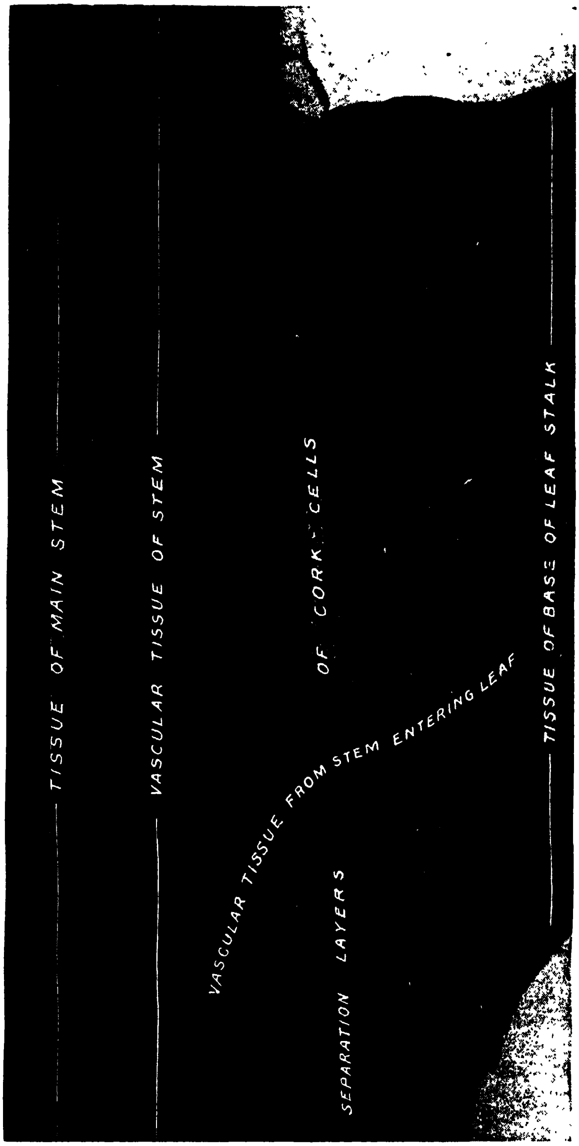
We have already referred, in a previous chapter, to the production of the substance known as *anthocyanin*, that wonderful colouring matter which is found near the surface. Whether this is one substance, or a group of substances, need not detain us here; the important point is that in most cases it probably is formed from the chlorophyll corpuscles, but in others growing in plants which have no green colouring at all.

Moreover, anthocyanin is not found in those parts of a plant in which chlorophyll is chiefly present, but rather in the flower, the fruit, the leaf-stalks, the stems, and the ribs of leaves, these being the paths or channels along which the foodstuffs travel. They are also those parts which are considerably exposed to the light, and it looks as if this material acted as a protection against certain rays. At any rate, anthocyanin in many plants is chiefly formed when the activities of the leaves are on the wane, which period corresponds in our country with the onset of the cold weather. We are not now speaking of evergreen leaves, in which substances are formed which are not changed by either frost or drought. But where we have a definite winter period the chlorophyll granules become of a

brownish colour, and retreat from the surface of the leaf, causing an evergreen leaf merely to appear of a darker green colour.

In the leaves which last for one season only, however, much more marked appearances follow the onset of frost. Everyone is familiar with the observation that these annual leaves fall whenever the frosty nights begin; and it must occur to one that if they did so without any previous preparation, and simply because on a given date the temperature fell, there would of necessity be a considerable wasting of those valuable substances which have been produced in the leaves. This, however, is provided for by the fact that, before the period arrives when the leaf is to fall, everything which is of value for the nutrition of the plant has been transferred from the leaf, either right down to the roots, or else into the branches, there to be stored up for future use.

The result is that the leaf which is left is little more than a skeleton, whose cells contain yellow granules and crystals which are of no further use except from the point of view of the production of the yellow colour of autumn leaves. Neither the yellow granules nor the crystals are of any further value for nutrition, but rather are they waste products, so that from this point of view the shedding of the leaf is a sort of process of excretion. The transferring of the nutritive materials from the leaf to the branches or roots takes place somewhat quickly. The leaves then lose their green colour, the chlorophyll granules being changed, and only the yellow granules remaining.



THE SEPARATION OF THE LEAF FROM THE TREE

This longitudinal section of the base of a leaf-stalk of horse chestnut shows the separation layers of cork cells three parts across, and cutting into the vascular tissue passing from the stem into the leaf-stalk.

The pigment anthocyanin, however, is produced in many plants during the transference of the leaf materials, and gives rise to various colorations of red, blue, and violet. It is red in the presence of acids which are common in autumn; it is blue if no acids be present; and if there is but little acid, exhibits a violet tint. These combinations of the yellow granules and the red anthocyanin give to the leaf the much admired orange tint. From the combination of these colours and pigments we get the appearances of yellow, brown, red, violet, or orange, and the greater the variety of trees in the district, the greater the variation of colour, of course, in the autumn tints. These tints are frequently exhibited in illustrations as being particularly splendid in tropical forests. As a matter of simple fact, however, the colouring is nothing like so vivid nor magnificent in the tropics as it is in Europe or Canada.

It should be remembered that autumn tints are by no means confined to the deciduous leaves of trees and large shrubs,

but also occur in smaller plants and perennials, being only the more noticeable in the trees on account of the large size of the latter. Examination of the leaves of quite small plants, however, will reveal the fact that the autumn tints of these are quite equal in brilliancy and beauty to anything seen in the leaves of large trees, and, in fact, approach the coloration of flowers themselves.

We have referred to the onset of frost in connection with the autumnal fall of the leaf. But it must not be supposed for a moment that the fall of the leaf is brought about simply by the frost. One can easily understand why this belief should be common. It simply follows from observing that a number of leaves fall after a cold night. The truth is that while the frost plays a part in determining the fall of the leaf, and hastens this process, it does not, as a matter of fact, account for the leaf becoming actually detached from the tree. This detachment is due to an actual vital process of growth, as the result of which a layer of cells is formed, called the *layer of separation*, which grows in amongst the strong tissue of the leaf, usually in the petiole, where it tears the older cells and causes a rupture. When this stage is reached, the very slightest cause results in the breaking in this position, and even in the absence of frost, or other external factor, the leaf will become detached. Outside factors, however, hasten the process, and when the separation layer has reached its full growth, every gust of wind and every onset of frost, and every thaw, is followed by the downfall of immense quantities of leaves, all of which have been thus prepared for the process. If we examine a leaf which has thus fallen, we shall find that the separation point is quite definitely obvious, looking as if the leaf had been cut through at that point.

SKELETONISED LEAVES OF THE POPLAR AND HOLLY

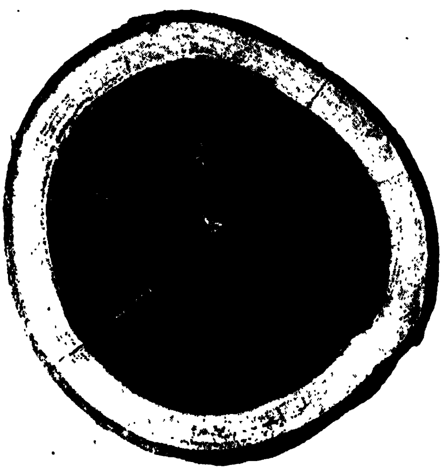
A very interesting point which may be observed in autumn is that the detachment of the leaves in some trees begins at the extremities of the branches, gradually reaching towards the centre of the tree. In other cases, the central leaves fall first, those at the tips of the branches being the last to go. The beech, the ash, and the hazel have the former habit; while the willow, the poplar, the lime, and the pear are examples of the foliage remaining for some time on the tips of the branches while the other portions are bared. Often, indeed, it takes the first snowstorm to clear the last leaves from the top branches.

The keynote of the whole interesting process of autumn leaf falling is that it depends, in the first place, upon the cessation of the process of transpiring in the leaf. The fall of the leaf, of course, means the loss to the plant of a certain amount of organic material in the framework of the leaf, which has caused the plant much effort to produce. But, nevertheless, the advantages to the plant are greater than the loss, and the advantage is not only with the plant, but the vegetation and life as a whole. The skeleton leaves are of great value for the common good, because they form the basis of the production of leaf-mould from which future plants obtain their nourishment. Hence we have compared the fall of the leaf to the process of excretion in animals, and the analogy is really quite a sound one.

Apart altogether from the æsthetic value of trees as objects of beauty, their chief use in the world to-day is, of course, for the production of wood, their most valuable product, and one that is becoming more and more valuable, largely on account of the careless way in which large tracts of country have been denuded of their trees without any attempt to plant new ones to replace them. In the "Industry" section of this work will be found an account of the forest industries, and the marvels that science is creating out of timber. Here, therefore, we need say nothing from the industrial point of view, but may confine

our remarks to the nature of wood itself. A glance at the cut end of a log will show that the wood is, as a rule, of two kinds, the *heart* in the middle, and the lighter kind of wood around it, the ***sapwood.*** Most trees that are useful from the point of view of timber show these distinctions. The difference extends deeper than mere appearance, because, while the ***sap-wood*** of even the oak decays in the course of a brief period, the *heart-wood* will last for years. Further, another look at the cut end of a log will show the ***annual rings*** to which reference has already been made, and which can be beautifully seen on any cross-section of an oak or pine. Those on the oak are easily counted, being marked by a line of little holes; those on the pine by a line of darker

wood, we may just briefly note the following facts. Most of it is lighter than water, but if left a long time in that element, it sinks. When sawn across, or split, the moisture in wood evaporates to the extent that one hundred pounds of wood will give off, on an average, about ten pounds of water. During the process of being dried, wood shrinks, but not equally in all directions. It shrinks about ten times as much from side to side as it does from end to end, heavy woods shrinking more than light ones. It is for this reason of shrinkage that we make our floors and panels and furniture, and so forth, from a number of small pieces, and containing many joints. The strength of wood is immense. To compress a cube of dry wood one inch



TRANSVERSE SECTION OF THE TRUNK OF A LABURNUM, SHOWING HEART AND SAP-WOOD

TRANSVERSE SECTION OF THE TRUNK OF AN OAK, SHOWING THE ANNUAL RINGS

The photographs on these pages are by Messrs. Hinkins & Son, J. J. Ward, H. Irving, and others.

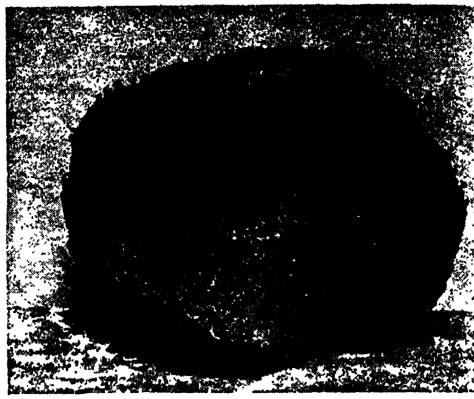
wood. The inner portion of the annual ring is that which is formed in the spring, the outer part being the summer wood. In many trees these two can easily be defined. Everybody is familiar with the expression, "the grain of the wood." This appearance is due to the fact that the wood is simply made up of cells in the shape of tubes, which have definite walls. These tubes were once filled with living protoplasm, but the wood consists of the framework of them. If the long tubes, or fibres, run straight through the trunk, we get what is called a wood with a straight grain. On the other hand, they may run in a spiral or wavy manner, and according to the direction in which the wood is sawn will the appearance of the grain differ.

As regards the physical properties of

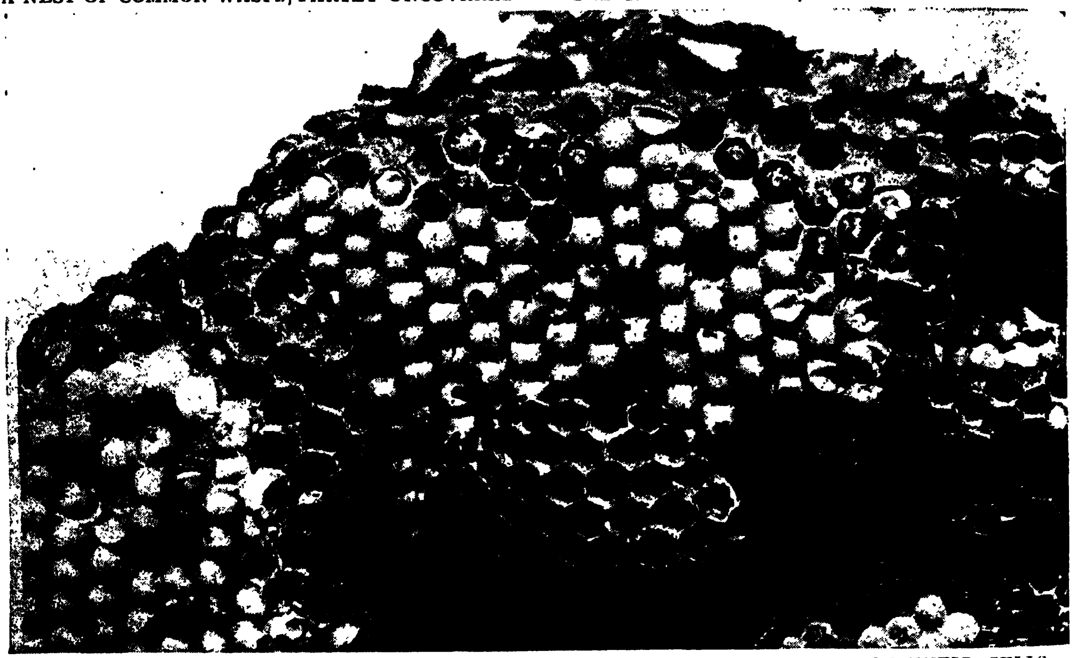
requires from six to ten thousand pounds pressure, and twice as much is required to stretch it. Wood is a very poor conductor of heat and electricity, and its temperature can be changed within far greater limits than can that of metals, without either becoming too hot or too cold to handle. Hence its value as materials for house-building. Its disadvantage, of course, is that it burns readily. Of its commercial value and the various products which are derived from it, the reader will find a description in Group IX. of this publication. In some countries wood forms the chief wealth of the people, and has done for many centuries, as in the case of the Cadore district—the mountain country inland from Venice which supplies that city with the piles that are its foundation.

THE WASP'S HOME INSIDE AND OUTSIDE

A NEST OF COMMON WASPS, PARTLY UNCOVERED

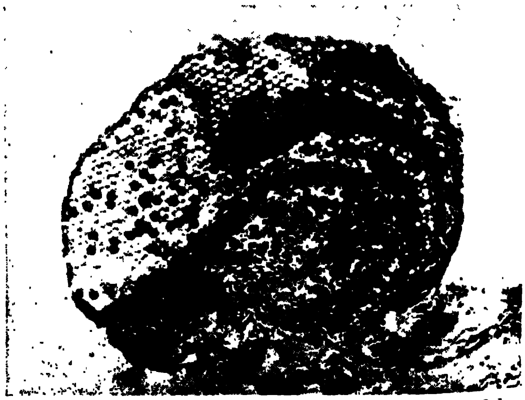


THE NEST REMOVED, SHOWING ENTRANCES



AN ENLARGED PORTION OF THE NEST PICTURED BELOW, SHOWING PUPÆ IN THEIR CELLS

THE TIERS OF CELL-LAYERS IN A NEST



THE UNDER SIDE OF ONE LAYER OF CELLS

The photographs on these pages are by Messrs. J. Holmes, P. Collins, O. Pike, and the Rev. S. N. Sedgwick.

ANTS, BEES, AND WASPS

The Unapproached Marvels of Combination and Organisation in the Insect World

SOME ROMANCES IN EARTH AND HIVE

It is a striking and puzzling fact that to find in the animal world any sort of parallel to the life of civilised man we have to seek, not among the animals physically most highly organised, but among the insects. Nowhere in the kingdom of Nature outside the family of man do we discover anything approaching the miracle of efficiency revealed in a common ant-hill, or any beehive upon which we may chance. The feats of the beaver are profoundly impressive, the union of forces among certain of the baboons, the co-operative hunting of certain members of the dog tribe, are features not lightly to be dismissed from mind; but, with all said, there is nothing in the animal world which really challenges comparison with the husbandry, harvesting, cattle-keeping, wars and slave-making of the ants; nothing even faintly rivalling the perfectly ordered system of the beehive.

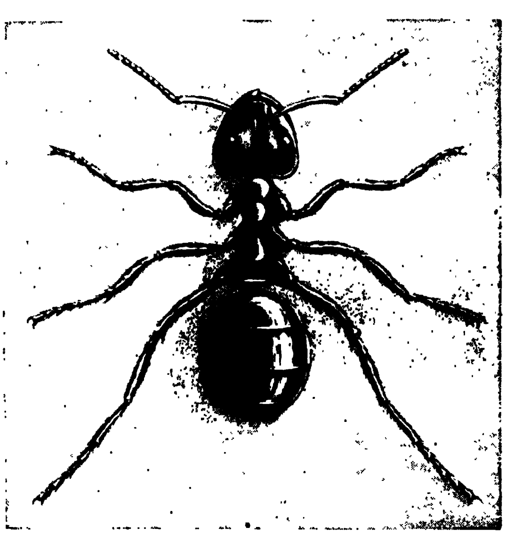
By what process these insects have advanced to this extraordinary development of communal life we do not know. Whether existing conditions indicate the operation of reason, as Lord Avebury, prince of English observers, believes, or whether they arise simply as the outcome of obedience to blind instinct in insects, experts cannot agree. This is not the place in which to attempt an answer to the problem which the united efforts of men who have devoted lifetimes to the study have failed to solve. M. Forel holds that certain insects may—possibly do—possess sixth and seventh senses of which we know nothing; Lord Avebury believes with Darwin that they are gifted with a "dose of reason." On the other hand, there are the sceptics who, denying reason to a dog which cannot free itself from a prison by the art of the picklock, sniff with incredulity or worse at the results of careful experiments by such men as Lubbock, begun before some such critics were born, and continued after they had written their theories. Only by laborious personal investigation can the man who would grapple the mystery decide for himself to which side he shall incline.

The insects named at the head of this chapter are all members of an important order called the Hymenoptera, four-winged insects, which include saw-flies, wood-borers, galls, and parasitic wasps, ichneumons, spider-killing wasps, solitary and social wasps, and solitary and social bees. Between 30,000 and 40,000 species are already known, and it is conjectured that four or five times as many remain to be named. It will be noted that, while a main characteristic of the order is the possession of four wings, the majority of ants have no wings. This, however, is the outcome of specialisation which has given the ant world a unique place in the animal kingdom. There are three different forms of ants—the queen-ants and the male ants, both of which forms possess wings; and the neuter, wingless workers, which enormously preponderate.

An ant colony may be formed either by a solitary queen or by several queens. Within her native home the young queen, in company with other queens, winged males and workers, has shared the common lot and labours of the establishment. She has stored immense reserves of energy within her little frame, and upon the appointed day soars in the air, which becomes blackened with the queens and males of other colonies. It is her first flight, and her last. She returns to earth to begin her nursery duties. The males set out upon the same day as the queens, and their career ends within a few hours of the flight from the nest. They die that day; they may be destroyed by larger enemies, or they may

sink to earth, to die by the wayside. They never return to the nest. Their part in life is played, and with them, as with the drones of the beehive, the curtain is rung down the day that it rises upon their career as Benedicts. The future lies with the queen and the workers.

Chance, so far as we can see, dictates to some extent the future of the queen. She may seek an establishment in which other fertilised queens are already in residence; she may be carried by workers to such a home; or she may select a suitable isolated spot, and there create her own little dwelling. Should the latter be the course, she must patiently await the maturing of her eggs, the slow development of her firstlings, which in this case appear as small though otherwise normal workers, who will take over from her the duty of tending succeeding eggs and young. In circumstances such as these the queen-ant is said not to leave the nest which she makes, but to subsist upon the reserves of tissue built up by her abundant feeding during her time in the nest from which she emerged. She must feed the larvæ with salivary secretions, and, out of her own substance, keep the little family going until the first brood are ready to forage for her. The workers now rapidly extend the city. They make tunnels and chambers in all directions, upon a methodical plan. The proceedings are practically identical with those in which workers are from the first installed. In either event the queen, who has left the parental nest winged and light as air, begins her serious work in life wingless.



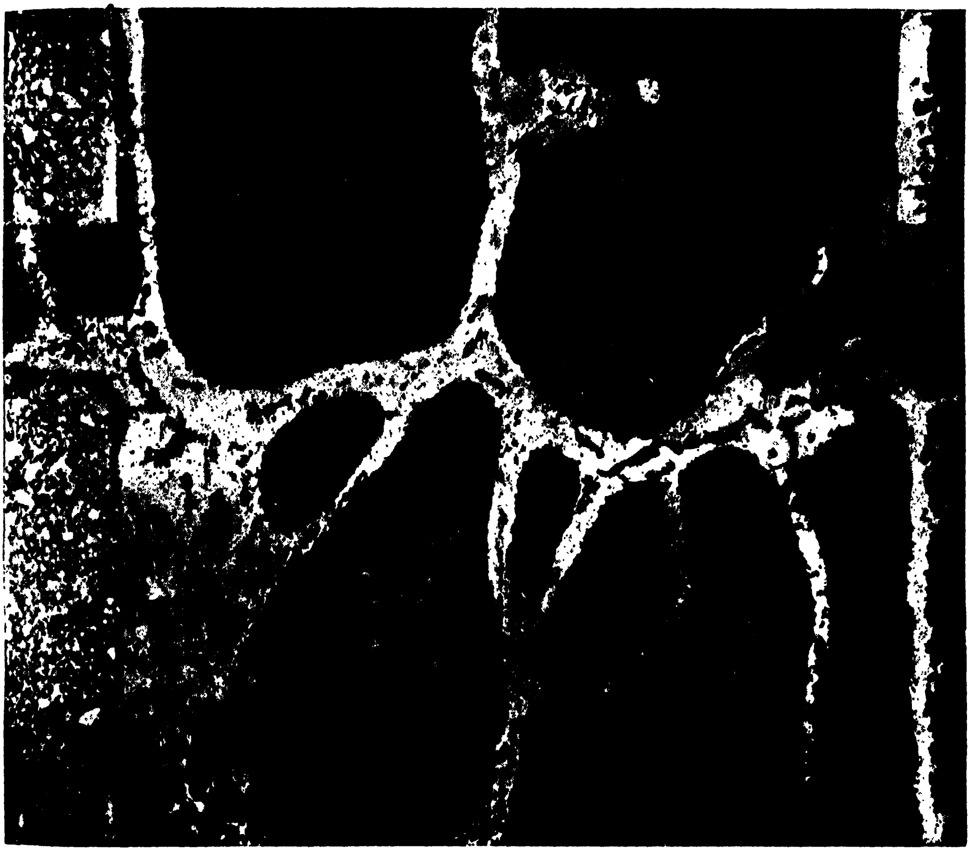
THE WOOD-ANT, HIGHLY MAGNIFIED

Upon her descent to earth, if she be alone, she either bites or breaks off her wings. In the case of one which descends in the midst of workers, the latter may relieve her of all temptation to further flight by themselves biting off her wings. With these workers about her, the now terrestrial insect is in good case. She may eat her fill of the food which the workers bring in. They take the eggs as she lays them, place them in nurseries, carry them from day to day from one gallery to another, even bringing them out of the nest into the sunshine, then restoring them to an underground gallery at night, so that throughout their period of incubation the eggs shall receive due measure of heat and moisture. The eggs hatch, according to the nature of the season, in from fourteen to thirty or even forty days. Small, white fleshy grubs emerge, legless, conical in outline. They are quite helpless, of course, and have to fed by the workers with food which the latter present in a semi-digested form. Here again the nature, and even the period, of the season determines the rate of growth. While under favourable conditions the larvæ may reach the chrysalis form in the course of a month or six weeks, some species live through the winter in this stage, requiring the unremitting attention of their nurses throughout that period.

The chrysalis may be either naked or it may be invested in a neat silken cocoon. The ants' eggs of commerce, by the way, are merely the cocoon-clad pupæ of ants, not the eggs, which are tiny, yellowish-white objects. Needless to say, the pupa or chrysalis takes no food. The feeding is done in the larval stage; and the seemingly miraculous transformation effected within the pupa-case is wrought as the result of nourishment already assimilated. A shapeless grub begins the transformation; a perfect insect, fully grown, emerges. It is interesting to note that the new-comer cannot divest itself of its pupal cloak without assistance. It must be helped to freedom by the workers, who relieve it of its covering, straighten out its limp little limbs, wash and smooth and brush it with all imaginable tenderness, and, when it is able to trot about unassisted, teach it its duties in the nest and beyond, setting it to tidy and garnish, to fare forth and hunt, marking out the dangers which it should avoid, and so forth—a whole string of romantic "impossibilities" having been proved realities by observers of scrupulous precision.

The fact that this instruction is given ells against the man who holds that the work of these insects springs not from intelligence but from instinct. Instinctive actions are performed without previous training, as the result of a given stimulus. If the actions of ants were simply instinctive, the young ones would not need direction from the adults. It is arguable that the mere imparting of instruction by the adult workers is in itself an instinctive impulse. But where there is apparently selection for duty in the highly complicated economy of the nest, we must assume that more than blind instinct is at work behind the selective process. If the whole thing were instinctive, surely the instinct would become operative at the birth of the perfect insect, not in the adult, when infant forms await their training. The whole daily round of the life of the ant seems against the assertion that instinct alone guides, impels, and controls.

The marvels of that life, and the inference to be deduced from it, are put in a nutshell by Lord Avebury: "When we see an ant-hill, tenanted by thousands of industrious inhabitants, excavating chambers, forming tunnels, making roads, guarding their home, gathering food, feeding the young, tending their domestic animals, each one fulfilling its duties without confusion, it is difficult altogether to deny them the gift of reason; and the preceding observations tend to confirm the opinion that their mental powers differ from those of men not so much in kind as in degree."



A SECTION THROUGH A NEST OF BLACK ANTS, SHOWING PARALLEL PASSAGES

Upon what is such a claim to be based, if we would prove that an ant is capable of acting intelligently in new circumstances, in which there can be hardly any question of the play of unassisted instinct? Lord Avebury submitted his ants to many experiments, and that upon which he most relied he himself has described: "My principal experiment was one in which I placed intoxicated ants [he anæsthetised them with chloroform] near a nest, thirty-eight being friends and forty strangers to the

colony. Of the friends, twenty-seven were taken into the nest and carefully tended; seven were dropped into the moat surrounding it, and four were left alone. Of the strangers, thirty were dropped into the water, one was left alone, and nine were taken into the nest. Of the latter, seven were again removed from the nest and carried to the water. Could anything more clearly show the reasoning power of ants?"

BRITISH SLAVE-MAKING ANTS KILLING THE SMALLER BLACK ANTS AND CARRYING OFF THEIR PUPÆ

By what means ant recognises ant we do not know. It cannot be the power of smell alone, though that sense, which resides in the intimably sensitive antennæ, is undoubtedly a great assistance for this purpose, as for the detection of food and for finding the way back to the nest. But it cannot be olfactory evidence alone, for ants resulting from eggs taken from one nest and hatched in another are rapturously welcomed upon being introduced as perfect insects into their native home; while their foster mothers, if put in with them, are at once destroyed. Possibly we shall never solve all the problems by which the life of these wonderful insects is complicated. We do not yet know all the senses by which they are actuated. It has never been proved that ants or bees *hear*. The voice of the ant no one pretends to have detected, but we all think that we know something of the language of the hive, and fancy that the sounds which we hear there are heard also by the bees. But, as M. Forel points out, no one has ever detected the auditory organism of a bee, removed it, and proved the insect afterwards deaf. That ants and bees do communicate one with another is as certain as that they live, but it may be the result of tactile impressions; wireless telegraphy may have been in existence in anthill and beehive ever since ants and bees reached their present stage of development. If we cannot be certain upon this and similar points, it is equally impossible for us to speak dogmatically with regard to other aspects of lowly life which stagger human conceptions.

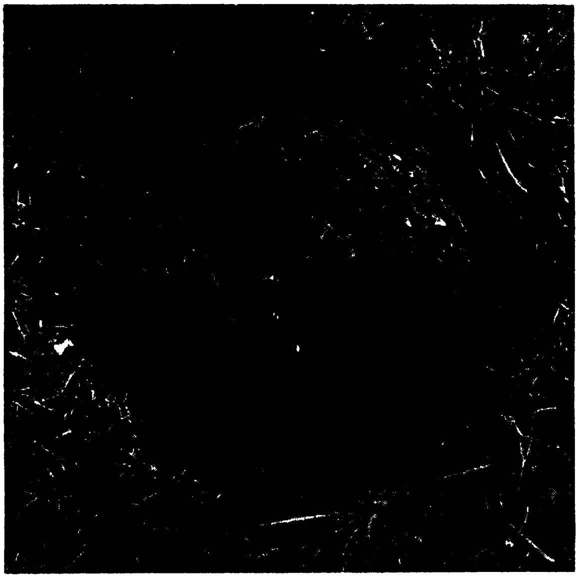
BLACK ANTS MOURNING A DEAD QUEEN

Something higher than instinct seems to be demanded for an insect which keeps and milks cows! This feature of ant life is one of the most clearly established in natural history. It is practised by more than one species of ants. The aphis, or greenfly, which deposits honey-dew upon the foliage or stems of vegetation, is the cow of the ant. In some cases the ants construct tunnels along the trunk of the tree or shrub which harbours the aphides, and in these tunnels form stables from which the cows cannot escape. In others, the honey-yielders are carried down into the ants' nest, and carefully maintained there. But the crowning wonder is that the ants purloin the eggs of aphides, carry them down into their nests, store and tend them during the winter as they store and tend their own, and, when the larvæ hatch, feed them as they feed ant larvæ, and eventually carry them into the open, and place them upon the very plant which constitutes the food of the aphis. And the

reward for all this is that the ant obtains the honeyed secretion of the aphis, which it "milks" by gently stroking it with its antennæ.

The ant colony may contain various other forms of insect life, which are represented as the pets and playthings of the owners of the city. That is as may be; it is not at all unlikely that the so-called pets are harmless parasites, flourishing upon the food supply of their hosts, who tolerate them because of their harmlessness. That they are tolerated is plain, for in an instant a colony of ants, with their deadly jaws and lethal equipment of formic acid, could rid their home of every intruder within it. The idea of plaything is, of course, not wholly to be disregarded, for in nothing do ants more closely resemble man than in their love of play. They leap and wrestle and gambol, in moments of emotional excitement, with the ardour and sportiveness of children—or kittens. They show grief and solicitude for the injured and ailing, and, in the case of their queen, mourn beside her dead body for weeks; whereas the dead body of a worker is at once remov[redacted] buried at a distance from the nest[redacted]

Of course, ants are not an u[redacted] blessing. The red ant, of the[redacted] a menace to anyone who approaches its nest; the ordinary brown and yellow ants work havoc with our food. The so-called "white ants," or termites, which have a marvellous organisation and homes, are appallingly destructive to property. To realise the effect of their attacks upon woodwork, one has but to inspect the exhibits on this subject in the Natural History Museum. The voracity of ants is almost incredible, their powers of discovering food extraordinary. The present writer, when a boy, stored for a night half a dozen caterpillars, with their food, in one of the old-fashioned wooden matchboxes, and hid them, from undesirable parental censorship, in a cupboard, twenty-five feet from the front door, beneath the step of which ants abounded. In the morning the box contained $1\frac{1}{4}$ caterpillars and a swarm of ants, which latter, the moment the box was opened, sought to add insult to injury by carrying off in concert the last survivor and the [redacted]t. Never [redacted]at night, [redacted]as could [redacted]ascertained, had ants made their appearance in that part of the house.



THE CHAMBERS AND PASSAGES OF AN EXPOSED BLACK ANTS' NEST

A SECTION THROUGH A [redacted]F A WOOD-ANTS' NEST, SHOWING [redacted]AND LARVÆ

A very late frost left one solitary plum as the harvest of an entire wall of fruit in a certain garden, and that plum grew in beauty and promise until the time of picking. The decision to harvest was left a day too

late. From a tiny puncture in the plum, when the latter was plucked, emerged ant after ant; it was full of them, though the only external evidence was so small as to be imperceptible until the fruit was taken in the hand. In the spring, when strawberries are being grown under glass, and in the early summer when peaches and nectarines are experiencing like treatment, the conservatories swarm with ants, but when the fruit ripens in the grounds surrounding, not an ant is to be found under glass, though the fruit-trees outside will be found practically alive with them.

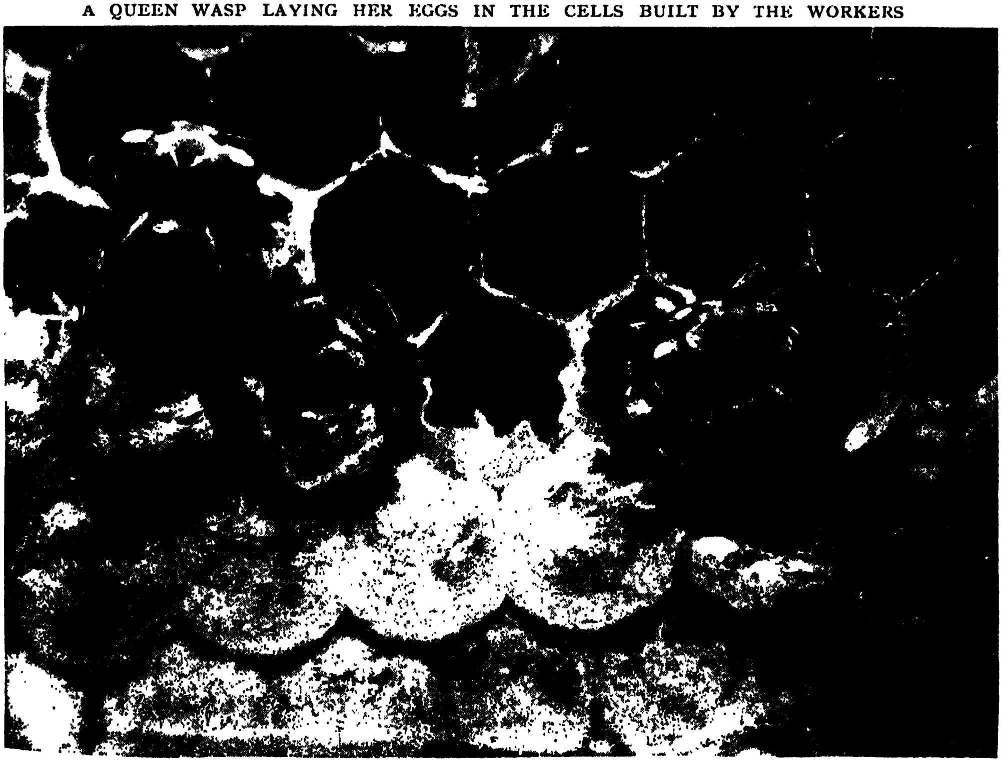
Ants may be troublesome enough in our own land, but there are worse abroad, where they are alternately bane and blessing. One such is the saüba, or parasol ant, which derives its second name from its carrying its plunder in an upright position upon its head; a terrible pest to South American cultivators, and especially to growers of coffee and oranges. These ants live in enormous colonies, whose external indications—far-reaching hillocks—convey no suggestion of the vast ramifications of the tunnels and chambers below ground. Bates gives us some notion by citing an experiment of which he was witness when a gardener in the Botanic Gardens at Para tried to ex- [illegible] made fires over some of the main entrances to the colony, and by means of bellows blew the smoke of sulphur down the galleries. Bates saw smoke issuing from many unsuspected outlets, one being seventy yards from the point of entry. Still larger colonies have been traced. Where the saübas are in abundance they make cultivation practically hopeless, killing trees and shrubs by biting off the leaves. These leaves they use as ceilings for their underground dwellings, but some they store in order that they may be able to eat the fungus which develops upon it. They enter habitations at night and devour food. Bates was besieged by them, and, after wearying himself in the attempt to stay their ravages by stamping on them, was driven to fire train after train of gunpowder in their track. It is to these ants that the redoubtable "soldier" ants belong—giants armed with terrific jaws. They accompany the ordinary workers when they go forth foraging, and do battle with any form of enemy, ant or other, which may threaten either the supplies or their bearers.

A QUEEN WASP HIBERNATING

Another pestilent ant is the fire-ant ((*Myrmica sævissima*), which Bates shows to be absolutely master of the situation in certain parts of tropical America. It is in such numbers as to be invincible. These ants have their cities under entire villages, and at their most active season drive away the human population. They enter the houses, and dispute every mouthful of food with the rightful occupants, and devour linen for the sake of the starch that it contains. "All eatables have to be suspended in baskets from the rafters, and the cords well soaked with copaüba balsam, which is the only known means of preventing them from climbing. They seem to attack persons out of sheer malice. If we stood for a few moments in the street, even at a distance from their nests, we were sure to be overrun and severely punished, for the moment an ant touched the flesh he secured himself with his jaws, doubled in his tail,

RECENTLY LAID WASP'S EGGS IN THEIR CELLS

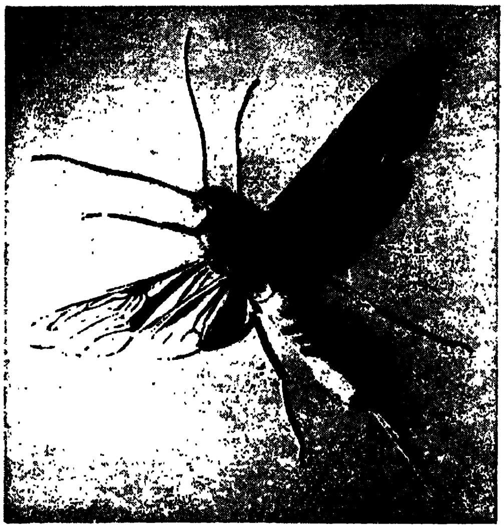
A QUEEN WASP LAYING HER EGGS IN THE CELLS BUILT BY THE WORKERS



YOUNG WASPS EMERGING FROM THEIR CELLS THROUGH THE SILKEN COVERINGS

and stung with all his might. When we were seated on chairs in the evenings, we had stools to support our feet, the legs of which were well anointed with the balsam." So were the cords of the sleeping-hammocks.

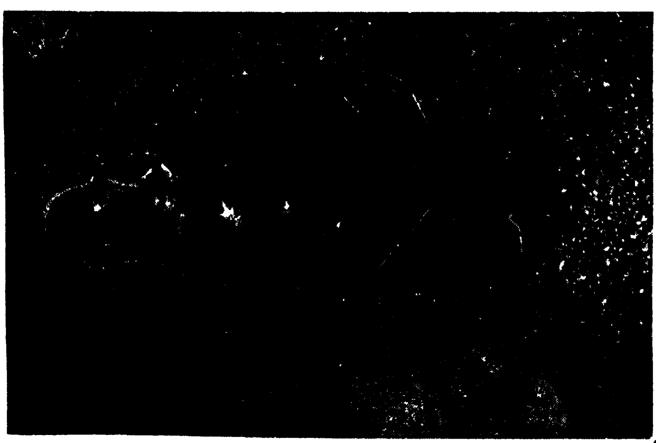
Still more formidable are the ecitons of tropical America, and the driver-ants of tropical Africa. Although not structurally alike, they are similar in habit. They march in irresistible numbers, and devour every animate things in their track. They enter houses and clear up every scrap of living matter, from beetles and birds to spiders and scorpions. Nothing can withstand their enormous numbers, their powerful jaws, and poison-charged strings; yet it is related that when not on the war-path they may be seen stretched at full length, extending their legs to be brushed and washed between the jaws and tongue of comrades, who finish the toilet operations by giving the antennæ a friendly wipe.



THE GIANT-TAILED WASP

This insect belongs to the wood-borer group of the Hymenoptera, and the tail is an ovipositor, not a sting.

Then there are the slave-making ants, which raid neighbouring colonies, kill the adults, and carry off the pupæ to rear them alive in their own nests, where the slaves in time become masters, doing all the foraging and fighting, feeding and cleaning their lords, who in time are wholly dependent upon their minions.

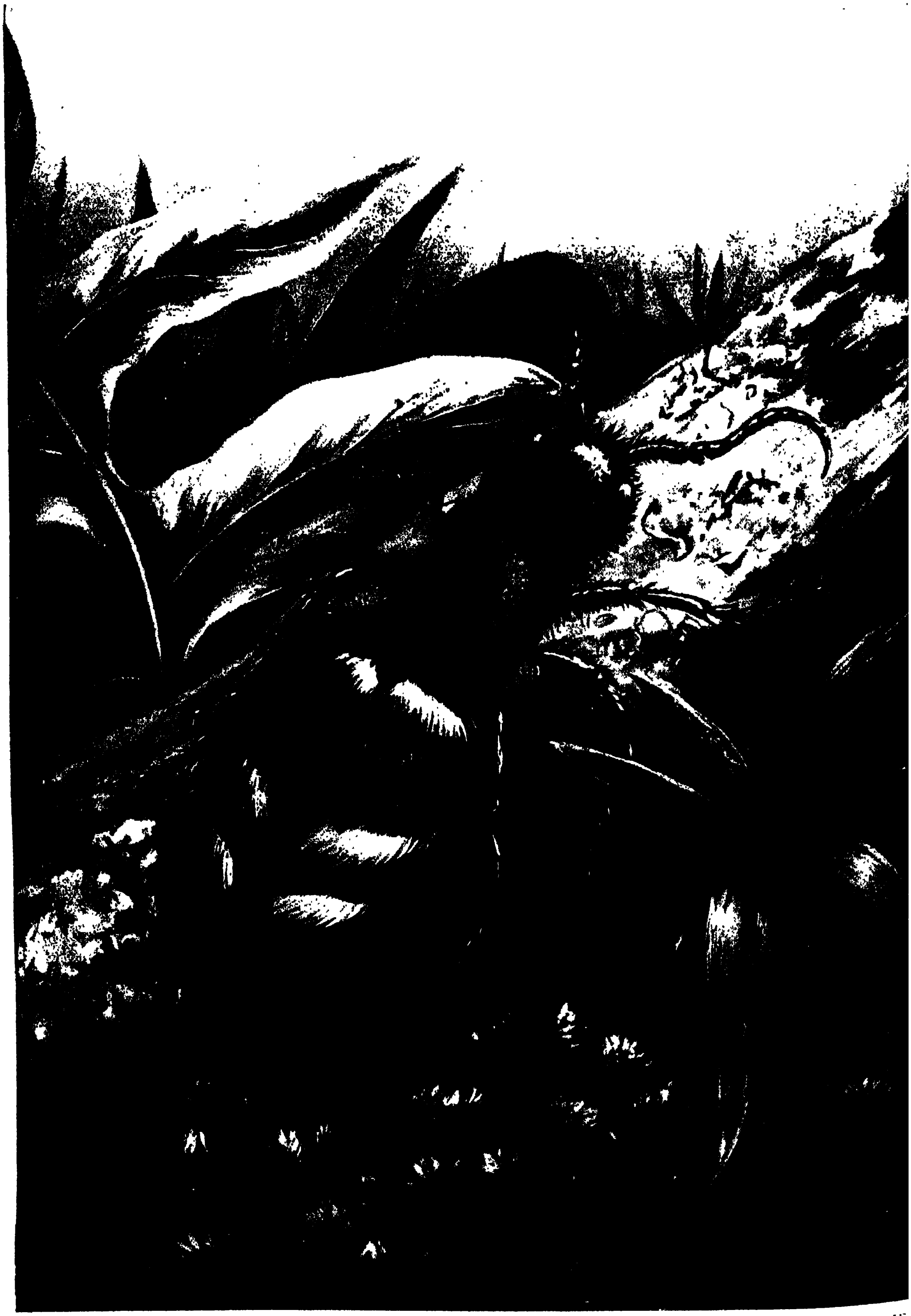


A SOLITARY DIGGER-WASP CARRYING OFF ITS CATERPILLAR PREY

One other curious ant we must note—the celebrated honey-pot ant (*Myrmecocystus mexicanus*), which is simply an animated storage depot for honey. The abdomen becomes enormously distended with its contents, and the hapless insects hang head downwards in the cells of the colony, ready to receive and conserve the honey brought in by workers, and finally to redistribute the store when the calls of hunger necessitate a demand upon the treasure. A curious fact noted in connection with these ants is that when a honey-pot dies, the workers do not eat the honey which it contains—the body is nipped in two, and carried out of the nest and buried.

That ants store grain, or rather seed, is a well-established fact. They exhibit great skill in preventing it from germinating, by shifting it from place to place to prevent its being stimulated by heat or moisture, and, in case of failure in this direction, by nipping off the radicle of the sprouting seed. But success is not gained in 100 per cent. of cases of this sort. Excessive moisture may prove too much for the efforts of the husbandmen, and they are in that case compelled to carry out their useless grain. Thrown away some little distance from the nest, the germinating seed takes root, and this led to the belief, long accepted, that the ant actually sows and cultivates its crop. Of course, this is a wrong inference, based upon insufficient observation. There seems no doubt, however, that a fungus-eating ant (*Atta sexdens*) deliberately plants her crop, taking her fungus mycelium, tearing up a portion, saturating it with a drop of fecal fluid, and carefully replanting

A LONELY MEMBER OF THE INSECT WORLD



THE EUROPEAN MUTILLA, POPULARLY KNOWN AS THE SOLITARY ANT, HIGHLY MAGNIFIED

FACING PAGE 3941

it. The process is clear enough. Whether the motive has been correctly estimated is, of course, not so easy to determine.

The beginning of a community of social wasps is not greatly different from that of the home founded by the solitary queen-ant. There comes a time in every autumn when only comparatively few wasps are alive in the land. The queens alone survive the winter. The queen goes forth late in the summer for her nuptial flight, and meets the male. Following this event, the queen seeks seclusion and shelter for the winter. The choice of shelter is not invariably suggestive of high intelligence. There is an attic known to the present writer to which queen-wasps resort in winter. How they get in is a mystery; there is no window, and the only visible access is by way of a trapdoor which is not open to wasps. There must be some opening in the roof known to wasps alone. Year after year queen-wasps repair to that cold and cheerless attic. The singular thing is that at the lowest point of the sloping ceiling there occurs a clear way into another attic where a tank containing 150 gallons of hot water preserves a pleasant temperature, yet never a wasp has been observed there. Only in this one mysterious chamber aforesaid are they to be found, cold and inert. Needless to say, the queens of that apartment are not permitted to add to the wasp population; of some threescore discovered there last winter, not one escaped.

Wiser wasps find safer shelter; and when the tide of life rises in the spring the queen seeks a place for a nest—it may be under a roof, or in a bank, or some sunny grass-plot by the wayside. There she rapidly constructs a series of cells of paper-like structure, formed from woody fibres and other vegetable matter. She deposits in each cell an egg. When the larvæ hatch, the queen feeds them with the nectar of flowers and the juices of fruits until the time arrives for the larvæ to assume the pupa form, when they close their cells, undergo their metamorphosis, and emerge neuter worker-wasps. The workers assist the founder of the colony in making more cells, and in feeding the larvæ. Tier after tier of cells is made, and an egg hatched from each. Towards the end of the summer young queens, and after that the males, appear. The earlier generations have all been neuters or undeveloped females. Some of these, however, are capable of laying eggs, which, unfertilised, as we say—though in all probability already fertilised in the nucleus received from the parental source—may develop into males. The young queens and the young males finally leave the nest, never to return. The workers which remain destroy the larvæ left in the nest; then themselves await death. So much for the life-cycle of the social wasp, which, although it eats great numbers of insects, is so destructive of fruit and so venomous an enemy of human beings as to be an almost unmitigated nuisance. The hornet is our largest wasp, and its sting is the most formidable in a formidable array of stings possessed by this undesirable family.

THE NEST OF THE TREE-WASP

Wonderful ingenuity is shown in the construction of nests by various wasps, and it is a fact that these insects were the world's first papermakers. But not all form nests of this material; some of the solitary wasps makes their habitations of sand, clay, or mud—quite efficient dwellings, though less admirable æsthetically than

the beautiful structure fashioned by the wood-wasp, *Vespa media*. In this group we find a singular method of furnishing a larder for the young. There being no workers, the parent has to provide food to which the larvæ upon hatching can help themselves. This purpose is effected by the capture of various caterpillars, spiders, etc. With terrible ingenuity the mother wasp leaves these alive, but paralysed, in the nest. She stings them in a vital part, and the wretched victims remain motionless, but living, to await the attack of the larvæ's powerful jaws. It seems a hideous transaction, but it is believed that the living prey suffer no pain.

Other remarkable members of the hymenopterous order include wasp-like forms of similar habits, such as the tailed wasps, which, with powerful ovipositor drill, bore nurseries for their eggs in the trunks of trees; the egg-wasps, which are parasitic upon the eggs of insects and spiders; the gall-wasps and the ichneumon wasps; the sphex, which preys in the main upon members of the grasshopper tribe; pompilus, which attacks even such large spiders as the mygale, or bird-eating spider.

THE NEST OF A HUMBLE-BEE, OPENED TO SHOW COCOONS

Finally, in the bees we have representatives of the order in which many naturalists finds chief delight. Here, as in the ants, are three forms—the queens, the males, and the workers or neuters. But the bees, unlike the ants, will have only one queen in a community. They seem to have solved the sex problem. The queen-mother knows what will result from the eggs that she deposits. She chooses a larger cell than the ordinary ones for the egg from which a queen is to be produced, and the workers reserve a special regal diet for such larva. But should circumstances arise necessitating the conversion of an ordinary worker-grub into a queen, the change can be effected within a given time of the production of the egg. They need but to alter the diet of the grub from plain fare to royal, and, lo! the intended Cinderella is born a princess!

We may briefly trace the life-story of a bee community from the point at which a fertilised queen leads forth a swarm from the hive to found a new settlement. Before taking their departure the bees gorge themselves with honey, in order that they may be sustained upon the way, and that their new home may not lack a larder. In a modern hive they would find foundation-cells already prepared for their reception, and would consequently have less labour. The process is more astonishing in one of the old skeps, into which they are dropped or encouraged to enter. Where the queen goes they will go—to death if need be. She is the centre, as she is the cause, of every swarm that we see, and she and they can be safely handled when gorged with honey, as they are for such a flight.

Within the skep is a great, black void, vast, in comparison with the size of the bee, as the most titanic cavern to a man. Here a home has to be built. Their only tools and materials are contained within their own organisms. They suspend themselves, one clinging to another, in the form of a curtain, from the roof of the skep, nearly to its base. Hour after hour they hang thus while secreting wax for the cells. This wax makes its appearance from glands beneath the edges of the segments of the body, and is rubbed off with the legs. In the meantime the entire hive has been cleansed by the remainder of the bees. The foundation-stone of the cells is laid at the apex of the hive. Wax, kneaded and rendered plastic, is brought up by bee after bee, is received, moulded and fixed, by a succession of architects, and a series of walls, each composed of six-sided cells, slowly grows downwards. As soon as a number of cells are ready, the queen, attended by a retinue of maids-of-honour, as her attendants are termed, goes from cell to cell, depositing an egg in each. There is a frantic competition at the outset between the queen and the workers, for she is anxious to lay eggs at a greater rate than they can build receptacles

while at the same time providing cells also for the storage of food. But the work goes on day and night, the queen, caressed and petted and fed by her maids, proceeding from cell to cell almost incessantly, and laying the foundations of the new community.

Before she has nearly completed her task the eggs first laid begin to hatch. The egg is a bluish-white little speck, attached for the first three or four days to the bottom of the cell. At the end of that time the minute grub emerges, to float in food supplied in readiness by the workers. When its head reaches the top of the cell, the nurses feed it—a treatment in response to which the larva waxes strong and fat. Food is coming in all day long from the workers, which, flitting from flower to flower, collect nectar and pollen. The honey and the pollen, or bee-bread, are separately stored, and there is a grading of the pollen. The grubs which receive the most nutritious food become queens — so few are favoured. It is a disputed point as to whether males result from the less nutritious food, but it is established that males predominate in the broods of hives poorly furnished with food, or where the queen is old and weak.

The grub, by whatever diet sustained, retires into its cell at the appointed time, and its cradle is sealed with wax by the workers. Within the cell the larva spins itself a robe of silk, and during the next nine or ten days effects the great change from pupa to imago. It gnaws its way out of its prison-cradle, and, after gaining strength, joins the workers in their task of scavenging or engineering, in the cooling and ventilating of the hive, a design effected by relays of bees vigorously fanning with their wings, and so maintaining a continual current of air. But if the young hopeful should prove to be a royal princess, the case is altered—she may not appear with such little ceremony. Princesses may not emerge while the old queen is in possession, or she will slay them. We have by this time, perhaps, got ten thousand eggs in the cells, and, it may be, twice as many larvæ, and a proportion of workers, and there will be seven or eight princesses. The colony is therefore well established; so the queen must lead forth an army to begin afresh; she has thousands of additional eggs to lay. She goes before the princesses make their appearance. As soon as she hears their murmur within the cell she is filled with fury, for queen cannot tolerate queen, nor even princess. She will, if permitted, approach the cell, and, with a thrust of her sting, kill the young life within it. But here the workers, ordinarily so complaisant, interfere to prevent her; they are wiser than their mother and ruler. Foiled, she leads forth another swarm, and later a princess emerges from a royal cell, to be attended by the remnant of workers remaining. She takes her nuptial flight and returns to the hive, where, in due course, she will head a swarm to found a colony of her own.

A DIVIDED SWARM OF BEES

Should queen and queen meet in a hive, a fight to the death results, but a wonderful provision of instinct, if such it be, prevents their simultaneously taking advantage of the opportunity to strike a blow when to do so would mean the death of both and a queenless hive. From such a posture both withdraw, to renew the fight upon such terms as shall ensure the survival of one. Towards the end of the summer, when it is undesirable that more swarms shall leave, the newest queen goes round to such cells as contain princesses, quietly puts each occupant to death, then settles down to her domestic duties in peace.

The importance of bees to mankind can hardly be over-estimated. They are the only insects in Great Britain to enjoy an Act of Parliament of their own. Owing to

a highly infectious bee-disease, which has spread throughout the country, the Government has had to seek powers to inspect hives and prohibit the importation of infected bees. The hives in England and Scotland at the present time are stated by the Government to be worth a million sterling. Rural England is even now only just beginning to realise the great value of the bee. Experts declare that bees may make all the difference to the small-holder between comfort and comparative penury. There is a constantly growing demand for honey, the retail price for which is a shilling a pound, and the cost of the little money-spinners is quite insignificant.

The value of these insects to the country is, however, infinitely greater than can be reflected in returns from the sale of honey. Bees mean abundance of fruit in orchards which would be otherwise sterile or practically worthless. Three years ago the fruit-growers of the United Kingdom were advised by the Board of Agriculture to keep bees about their plantations. The reason is obvious. From an ordinary stock of bees there are from 10,000 to 15,000 flying from blossom to blossom from early morning till evening. The result of cross-fertilisation by bees is to produce greatly enhanced yields of fruit, and better and larger fruit at that.

A single example, cited with natural satisfaction by the officers of the British Beekeepers' Association, is better than a volume of argument A fruit-grower in California had under cultivation forty acres of peach-trees. Being dissatisfied with the yield, he decided to cut down the trees and plant others, which he hoped would be better bearers. By the advice of the President of the British Beekeepers, who had noticed that there were no bees upon the fruit blossoms, he purchased two colonies of bees. The beneficial results were evident the same year, for there was at once a fair yield of fruit. So satisfied was he with the experiment that the owner enlarged his stock of bees in the following year, with the result that his trees were laden with excellent fruit.

The breeding of improved stocks of bees is now a well-organised industry, and Japan has profited by the calling, having introduced a number of fertile queens of approved lineage to take the place of her improvident own. The native Japanese bee is a sluggard, taking no thought for the morrow, but living pretty much on the terms of the wasp. The result was that not a tithe of Japanese fruit-trees were cross-fertilised, and not a tithe bore good pears or apples. Queen-bees at from £5 to £10 apiece have been taken to Japan within recent years, and the results are said to be excellent.

THE QUEEN BEE BEING FED BY THE WORKERS

The only objection that any of us can have to the bee, this beautiful, nectar-fed creature of the sunlight, is that it is apt to sting. But a bee has been reported, in the "Times," of a strain harmless to handle. The bees are said to be active workers and not liable to disease.

A WIRELESS WORLD OF MIND

The World that Lies Beyond Our Senses, and the Efforts of Science to Penetrate It

IS THERE SUCH A THING AS TELEPATHY?

If we cannot admit the existence of the mind even in the man who is awake and confronts us, but have to look upon him as merely an automatic machine, certainly we need not trouble ourselves with any further research, called psychical, for our study of man is already complete. But if we reject the mechanical theory, lately revived, which Ruskin, forty years ago, briefly defined as the view that "there is no such thing as a Man, but only a Mechanism," and if we do recognise the evident mind in ourselves and others, we soon find that we are led on to ask whether there may not be even more mind in man than is at every moment, or at any moment, evident. Every now and again we have hints in the behaviour and experience of ourselves and others which suggest that things are going on in the mind of which we are scarcely aware until some special occasion reveals their results. Strange stories are told which suggest that one mind may communicate with another by a wireless, if not an etherless, medium, or by no medium at all, and in spite of obstacles placed by all the media of the material world.

No doubt fancy, hallucination, tricks of memory, invention, the principle that every man should leave a story better than he found it—all these are responsible for much of what we hear about. But enough remains to be impressive and suggestive, if we are patient enough to listen. Hence some few bold people, not many years ago, founded a society for the study of these phenomena, if they really exist, by scientific means, and in the scientific spirit. Hitherto they had been exploited by those who wished to make money out of them, with but few exceptions. Such extraordinary cases as that of D. D. Home, whose memory is preserved by Robert Browning in "Sludge the Medium," and who persuaded Mrs. Browning, but not her husband, that he had "materialised" for them the form of their dead child, required the right kind of investigation. Then there was the celebrated medium Mrs. Piper, of Boston, who had deeply impressed several critical students of psychology. In this country, Sir William Crookes had recorded strange experiences; and while Mr. Maskelyne and his assistants at the old Egyptian Hall could perform apparent miracles by natural means, it still seemed that there was something more even than supremely clever conjuring to account for.

Hence the foundation of the Psychical Research Society, both in America and in this country. Across the Atlantic, such men as the late Professor James were deeply interested. Here were Mr. A. J. Balfour, the late Mr. Frank Podmore, Mr. Alfred Russel Wallace, Professor F. W. Barrett, F.R.S., Sir Oliver Lodge, and many others; above all, a man of genius, the late Mr. F. W. H. Myers, whose book on "Human Personality, and its Survival of Bodily Death," may some day be reckoned one of the treasures of our literature. This society owed too little to the sources which should have nourished it. The physiologists and medical men in this country fought shy of it, partly because of the orthodox materialism of the medical sciences in the last quarter of the nineteenth century, and partly because they preferred not to be associated with anything thought "cranky." Professor Henri Richet, of the Chair of Physiology in the University of Paris, has done not a little, however, to compensate for the attitude of academic and official science in this country.

The Churches were not encouraging or helpful, the idea still prevailing in many quarters, and conspicuously in the Roman Catholic Church, that inquiry into such subjects as the life after death is blasphemous and obscene, these being the sacred mysteries of which the Church and her accredited

representatives are alone the repository. The best help should have come to the new society from the psychologists—from holders of Chairs and Lectureships in our Universities—a small band, of course, but important and highly qualified. They gave as little help as anyone else.

Looking at the "Proceedings" published by the society, and the investigations in which it has interested itself, and the difficulties under which the work began, it is impossible to deny that the society has been a most valuable and illustrious force in the advance of thought and knowledge. That opinion seems to receive additional confirmation from year to year.

The word "telepathy," or feeling at a distance, was introduced by Myers to describe the transference of thoughts, ideas, feelings, or other psychical facts, from one person to another, without the evident use of any of the media which physics can name, and without the help of any of the sense-organs which physiology can name.

The Presumptions in Favour of Telepathy Suggested by Ordinary Experience

That was before the days of wireless telegraphy, but it is familiar to every reader of POPULAR SCIENCE that wireless telegraphy and telephony use the physical medium called the ether, and that the equivalent of a sense-organ is used to detect the "wireless" waves. Telepathy involves no obvious machinery for the making of waves, no known medium to convey them, no sensitive apparatus for recognising them. That, at least, is the apparently necessary assumption, if telepathy be a fact—which is, of course, the primary and cardinal question. If we are to avoid the too frequent confusion between the demonstration of a fact and the explanation of it, we shall be wise to consider, first, the evidence for telepathy; and then, if we think desirable, the possible explanations of it.

Many presumptions in favour of telepathy are suggested by ordinary experience; and the task of science, in this field of "psychical research," is the same as in all other fields—to try to verify and define what ordinary experience suggests. For the interpretation of experience is ambiguous under ordinary conditions. You and your companion both start to speak at once on a new subject, and it is the same subject with both of you. You hum a tune, from the very point at which your companion had just silently left it. You feel you must go home, for something has happened to your friend far away, and there is the telegram announcing his death when you arrive. Experiences of this kind are more or less familiar to all of us, and we have to ask their meaning, in the sovereign name of science, as we have to ask the meaning of the anomalies in the motion of Uranus, or of the "Brownian movements" of particles seen in a fluid under the microscope. To ignore the experiences, or to *assume* an explanation for them, as orthodox physiological and medical science does, is to deny the essential idea of science.

Do Telepathic Messages Require a Special State of Receptivity?

We naturally begin by asking under what conditions these phenomena most usually occur. Are they apparently arbitrary, or are there certain combinations of circumstances, or certain states of the mind, in which the telepathic message is more likely to be sent or received? Many pairs of lovers, or close companions, would be found to say that they were mutually telepathic when together or when in the company of other people. Hosts of stories seem to suggest that the time of death favours the initiation of a telepathic message from the dying person. Many writers on the subject believe that a special state is required for the telepathic process, and that, for instance, we should *not* expect to find proof of telepathy under the formal and cold conditions of scientific experiment. What may be the truth of this we do not presume to decide, but the Psychical Research Society did make a large number of scientific experiments on this subject a few years ago, and they are duly recorded, or some of them are recorded, in its literature.

Sample Experiments Made Formally by the Psychical Research Society

In the judgment of several authorities, including Sir Oliver Lodge and the late Mr. Podmore, the evidence of telepathy is conclusive. Mr. Podmore's attitude was the interesting and reasonable one that he had certain records of phenomena to explain, which had to be accepted as facts, and were capable of only two alternative explanations. Either there had been telepathy, or there had been communications made to the living by the dead. Forced to choose between these explanations, Mr. Podmore chose the simpler and more intelligible one, and so found himself compelled to accept the existence of telepathy as a fact. But the experiments of the Psychical Research Society were specially directed to the demonstration of the simple fact of telepathy in ordinary circumstances,

and it is upon these experiments that Sir Oliver Lodge bases his belief in telepathy as a proven fact of science.

A few words will suffice to show the kind of experiment made. Someone would sit in a room with a pack of shuffled cards in his hands, and successively turn up their faces; while a second person, on the other side of a screen, or in a second room, would try to receive, from the mind of the first, an impression of the cards as they were revealed, and note them accordingly. Obviously experiments of this type can be varied indefinitely in details, but this indicates their principle sufficiently. Other experiments might deal with the attempt to transmit the idea of drawings or paintings from the mind of the person who looked at them to the mind of the second person, who would try to draw what came into his mind. In these experiments great care was taken to prevent all possibility of accidental *seeing* by the second person, or of the influence of the hypnotic state and its allies, upon the senses of hearing and vision, which may and do often become most extraordinarily heightened in intensity, so that hearing and vision would be possible where ordinarily they were quite impossible. But the experimenters tried their best to transmit and receive, concentrating the attention upon the experiment.

Can the Psychical Society's Results be Explained as Coming by Chance?

The believers in telepathy are fully entitled to say that these are not at all the kinds of conditions in which they expect telepathy to be possible, and if the experiments are to be regarded as inconclusive or negative that objection to them must be remembered. But, in fact, the experiments are regarded as having been successful. Several years ago the present writer asked for an opportunity of studying the evidence for himself, and this was granted him by Sir Oliver Lodge. He visited the society's rooms, saw the conditions of the experiments, and reviewed the published accounts of them. The most crucial experiments were those made on the lines first described above—the transmission of the numbers of playing cards by means of telepathy. It is possible to calculate the chances of a successful guess, and to estimate how many such successful guesses there would be in a given number of individual cards turned up. When these expectations of accuracy are pitted against the descriptions of the cards actually made under the conditions of the experiments, it was found, very frequently, that the proportion of successes was higher, and sometimes very remarkably higher, than the chances of pure guessing would permit. All possibility of collusion or any form of dishonesty, as well as of actual seeing of the cards by the second person, or his hearing of the numbers unconsciously whispered by the first person, may be dismissed as wholly out of the question.

Were Those Results Chosen by an Unconsciously Favourable Selection?

Only one disconcerting observation falls to be made now. In the published accounts of the experiments we are told by Sir Oliver Lodge that they were very numerous, and that those published are only a selection from the more successful ones, but a selection quite sufficient to enable us to draw the evident inference. But, unfortunately, where the whole question hinges upon the proportion the successes bore to the proportion which the laws of chance would permit, a selection of "successful" experiments—*i.e.*, those in which the ratio was above the expectation of chance—is worth exactly nothing at all. One might just as well publish only those in which the ratio was below expectation, and argue that telepathy gave wilfully misleading information. The simple truth is that the publishers of these experiments unconsciously assumed that telepathy was at work, and explained and published the "successful" experiments; while the other experiments were regarded as unsuccessful, the telepathic process being presumably not in action. The interesting question arises whether, if all the experiments had been published, successful and unsuccessful, the ratio of successful guesses—we cannot keep the word back—to the ratio of expectation according to chance would not have been exactly one to one.

The Scientific Attitude of a Blank Denial of the Possibility of Telepathy

This criticism was not replied to when published, and scarcely seems to admit of reply. Here, therefore, we shall not be able to regard the fact of telepathy as proved by the experiments referred to. It by no means follows that telepathy is *dis*proved. The present writer is indeed inclined to believe that telepathy does occur, perhaps under such conditions as those of the foregoing experiments, perhaps only under exceptional conditions, or between persons who are attuned, and in whom what, with the help of a term from wireless telegraphy, we may call a *mental syntony* has been established. At any rate, there is one statement which must be made in the

name of impartial science. It is that the denial of the possibility of telepathy, in the name of science, is itself utterly unscientific. There is no scientific reason whatever why telepathy should not occur, though science is entitled to ask for crucial evidence that it does occur. There is, indeed, no difficulty in framing quite reasonable hypotheses as to the way in which telepathic transmission may occur, and the now well-known facts of wireless telegraphy and telephony may be called in aid.

May not "Waves" be Started from Brain to Brain?

Between us all there is the continuous medium called the ether. It is believed by physicists to be absolutely omnipresent. Matter is regarded as a kind of local modification of the ether, as an iceberg is a local modification of the ocean. The brain of every one of us is thus a material organ in an ocean of ether. When we have an idea, say, of the three of diamonds, no doubt there are certain physical changes in the brain which correspond to and accompany the formation of that idea. These physical changes, which every physiologist will admit—and, indeed, strenuously assert—not only may, but must, initiate disturbances in the ether, and the nature of the disturbance must depend on the nature of the brain-change. The naïve idea that the disturbance started by the brain must be confined by the skull is disposed of when we remember the Röntgen rays, and the fact that such conditions of the ether as go with a thunderstorm can certainly make themselves felt through the cranium. If, further, we consider what happens in the wireless telephony which we call speech—though we may never have thought to call it wireless telephony before—we shall see that there is no difficulty in conceiving how an ethereal disturbance of a specific kind, starting in one brain, might reach another, and be appropriately interpreted by another.

Is it Possible for Spirit to Speak to Spirit Without any Material Intervention?

No doubt this is a mode of sensation—we can call it nothing else—to which the physiologist is unable to quote a parallel. If it occurs, it is most conspicuously unlike what we know, and have here studied, of other modes of sensation. They all require sense-organs. Further, we found that the brain itself, when directly stimulated, say, in the area where the sensation of touch is felt, feels nothing! It may be touched, squeezed, cut, in the areas where tactile and painful sensation have their centre, but neither the sense of touch nor that of pain is aroused. The brain can be stimulated only through the appropriate channels of these senses. But, in the apparent case of telepathy, no sense-organ is required, and the brain must presumably be excitable directly through the cranium. The only alternative, still assuming the reality of the phenomena we are trying to explain, would be to abandon any rational hypothesis at all, and assume that "spirit to spirit can speak" without any relation to the material world and its conditions.

Before we leave this interesting but deplorably obscure subject, one other asserted fact is worthy of note, for, if it be true, it may have much bearing on the explanation of the asserted phenomena. It is that telepathic communication is made far easier if the recipient of the communication be in the hypnotic state. Here, as the reader will see, we do not feel ourselves in a position even to determine certainly the existence of telepathy at all; and evidently, therefore, we are not in a position to vouch for this assertion as to the influence of the hypnotic state upon the telepathic process.

The Reasonableness of Greater Susceptibility in a Hypnotic State

But it is, in itself, a most reasonable assertion, for in the hypnotic state the activity of the subject's senses is in abeyance. So far as practically all external things are concerned, the senses are asleep, though the subject himself or herself is by no means asleep, but in some queer respects intensely awake. Now, if telepathy be a fact, and if its *modus operandi* be by the direct passage of ethereal disturbances to the percipient structures of the brain, we can very well believe that such passage will be most likely to be effective when the brain, or some deep "faculties" of the brain, are awake, while the ordinary channels of sense are inoperative, the brain declining to take any notice of what passes through them.

So much for telepathy; and if the reader feels that this discussion of it is less than completely satisfying, and wishes that we knew more, so does the writer. The future will do better; and we must remember, if the difficulties of the subject seem formidable, and our assured knowledge small, that only within the last few years have honesty and skill paid any attention to it, and that other sciences, now great, were perhaps not too promising or successful in the first decade or two of their existence.

However the case may be as regards the influence of hypnotism upon telepathy,

at least we are certain that, when anæsthesia, sleep, hypnotism, or any other agency has arrested the activity of what we call the conscious mind, mental processes of some kind are still going on. There are depths of mind beneath the surface of consciousness, and we must try to explore them.

The purely physiological view, as entertained by such a distinguished survivor from nineteenth century materialism as Professor Schäfer, assumes that the evident consciousness of a man is a kind of curious "phosphorescence," as Bergson says, that accompanies the working of certain parts of his brain, and that, if those parts of the brain be thrown out of action, then the sole psychical phenomenon—or "epi-phenomenon"—of the man's being ceases. This view provides us with one answer to the old question as to the whereabouts of a man when he is asleep. According to materialism, "there is no such thing as a man, but only a mechanism." If the "phosphorescence" is in abeyance, the man is still there, or, rather, the mechanism is still there. The so-called man is a mere accidental "epi-phenomenon" of certain states of his brain.

The Continuous Psychical Life of Man Under the Veil of Sleep

We might as well ask where is the electric lamp when the current is not switched on, and the incandescence ceases. The lamp is as much there as ever, but the conditions which caused the incandescence are in abeyance. To those who are satisfied that the analogy between the brain and the lamp, the mind and the light, is more than an analogy, there is no more to say.

But we who are not to be fooled by analogies that ignore fundamental differences, and who know that the mind which perceives the light, and the light it perceives, are not at all comparable—have still to answer the question, Where is the psyche of the man, the man himself, when he is asleep? To thinkers in the past this was a serious difficulty, and no wonder. They had no evidence, or did not identify the evidence they had, to show what we now know—that the psychical life of the man is still going on continuously under the veil of the anæsthetic or the sleep. Now, if we are asked what has become of the identity and being of a man who is asleep or anæsthetised, we can confidently reply that only a certain limited, though very obvious, set of psychical facts are in abeyance, and that the deeper psychical life of the man is flowing on undisturbed.

It was said in the last paragraph that our predecessors did not identify the evidence they had of the subconscious mind. We were referring to the evidence of dreams. Here is a subject which superstition, sham religion, quackery, and chicanery have exploited ever since human history began, and which they still exploit, at this very hour, in every quarter of the globe. It is none the less, or all the more, a fit and necessary subject for the inquiry of science, which it at once begins to repay. Let us briefly remind ourselves, in the first place, of past theories as to dreams, and then we shall be better prepared to consider the theories which modern knowledge seems competent to frame.

The Theory that Dreams May Have Led to the Evolution of Religion

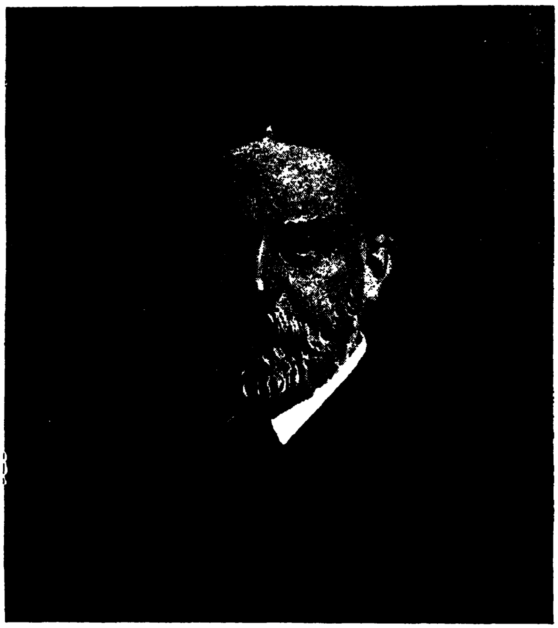
If we are to follow the celebrated and ingenious reasoning of Herbert Spencer, it was upon the observation of dreams that primitive man first based his theory of a future life. According to Spencer's interpretation of the argument in the primitive mind, it was observed that, while a man's body lay in sleep, the man himself might be roaming afar, doing all manner of things, as the man would himself narrate, when his spirit returned to his body and he awoke. Now, this was clear evidence of the existence of the soul apart from the body. Hence there arose the doctrine to which the name of animism is sometimes given, though other writers, to our confusion, give it to the doctrine that stones and clouds and streams have spirits in them. The primitive thinkers argued, according to Spencer's theory, that if the soul could leave the body in sleep, and ultimately return, it must leave the body at death, and would return to it, also, some day. Hence arose the belief in the continued existence of the dead—for instance, of one's ancestors, and the fearful worship of them, lest they should do harm to the living; and so the phenomena of dreams may in some such way as this have led to the evolution of religion.

The Belief from the Earliest Times in a Self Beneath Ourselves

The historical and sociological truth of this theory do not concern us here. The point for us is that, untold ages ago, men observed that *some kind of psychical life* may exist during sleep. For the student of the history of ideas it is not without interest that this primitive discovery of the savage, from the facts of dreams, should be the newest discovery in the psychology

of today. In the language of Myers, we learn from such facts as dreams that, under the ordinary waking consciousness, there is another consciousness, or stratum of consciousness, which we have called the "subconscious mind," but to which he gave the often employed name of the "subliminal consciousness." This subliminal—*i.e.*, under the *limen*, or threshold—consciousness, or subliminal self, goes on continuously, whether the ordinary consciousness above it wakes or sleeps. Only under special conditions can we expect to observe the history of this self beneath ourselves. It maintains a psychical life of experience, invention, imagination, apprehension, remorse, and so forth, even when we ourselves are asleep.

In this sense, we are probably dreaming during the whole of sleep, though only a very small part of our dream-experience crosses the threshold of consciousness so that *we* can experience and narrate it. We may be dreaming all the night, quite normally and naturally, living our own interior lives, and the only dream which we talk about when we wake may be the acutely experienced dream produced by the noise that woke us, the only dream which rose up sufficiently into the level of the waking consciousness for us to recall it.



FREDERICK W. H. MYERS
Photograph by Elliott & Fry

But now let us pass to a second ancient theory of dreams, and consider what it has to teach or to suggest to us. It is that in dreams we may obtain knowledge of the future, or of facts which could be made known to us in no other way. In short, certain dreams are "veridical," or truth-saying, to quote a term much used in psychical research. Here at once we find ourselves before a very much more recondite and difficult question. There is no difficulty in accepting the view that dreams demonstrate the continuity of the psychical life of the individual underneath the apparent interruptions of normal or artificial sleep. On the contrary, that view is a contribution to our understanding of many other facts. But now we have it suggested to us, not merely that the *psyche* of the individual is alive and awake during sleep, but that it can receive psychical visitants, heavenly, earthly, or infernal, or, at any rate, can receive intimations from other psychical forces in the universe.

At this point the reader will doubtless be reminded of the asserted fact of telepathy—that the hypnotic state is peculiarly favourable to the reception of telepathic messages. Similarly, in sleep, the argument was that the suspension of the activities of the conscious self, which is directly concerned with the things of the material world, the visible here and now, renders the deeper or subliminal self freer for the reception of psychical influences from sources outside itself. Thus, "in a dream," the destiny, the duty, the danger of the sleeping individual may be revealed to him or her by some being who may perhaps be described as an "angel"—some messenger who, in Palestine, perhaps, or in France, tells a young girl what is her destiny, and arms her with courage to do almost superhuman things, believing that superhuman forces are behind her. Such dreams are associated with the senses both of hearing and seeing, and so the subject of them remembers "a vision in the night," and "a voice saying" wonderful and compelling words. Such words, such experiences, have made history; they have inspired lives of extraordinary ardour, heroism, and beauty; and so potent have they been that, to the common world, their subject is "possessed," or "hath a devil," or is a "witch," and may be burnt at the stake, as we burnt Jeanne d'Arc.

Faced with the records of such lives, the confident and destructive science of the nineteenth century contented itself with the

theory of fraud. People like the religious leaders of history, or Jeanne d'Arc, or the saints and martyrs and *illuminati* in general, were to be looked upon as clever inventors of tales which would impress the multitude; if you want a following from the mob, give it out that you had special information from the Deity last night, and they will pay you handsomely for it. That was the simple explanation which we were asked to accept. It owed what credibility it had to the fact that clever inventors of such tales are always to be found, in every part of the world, who strive to get for their own advantage what they see given to the mystics, the saints, and the inspired reformers.

But, like a good many more simple scientific explanations of the past, this was too simple. The theory of conscious fraud, which has been such a stumbling-block to the progress of our knowledge in these directions, and against which the Psychical Research Society has done so splendidly, had to be abandoned. It completely explains hosts of things, of course, but it is no explanation of a host besides, which alone matter. The discovery of the hidden wire by which a conjurer controls a ball at a distance is no explanation of the earth's control of the moon.

Visions and Inspirations as Facts that Science Has to Explain

But, unfortunately, ninety-nine people out of a hundred are content with the theory of fraud when they know, as we all know, that there is such a thing as fraud.

It came to be seen that the phenomena of dreams and visions and revelations and inspirations are real phenomena, as real as the red sandstone or the crystalline structure of snow. Myriads of men of science, of a certain concrete type of mind, faithful students of sandstone or snow, will never be able to realise that intangible phenomena can be as real as these things; but real they are, none the less, and science has to explain them if it can. If the dreamer, the prophet, the pioneer, the poet, really had such and such an experience, and, above all, if it proved veracious, the facts have to be explained. What caused them, or who caused them? So science makes a new reply, in terms of its newer knowledge. This knowledge is very largely derived from the study of the insane, and very few people realise how new it is, for the insane we have always had with us. But scarcely more than a century has elapsed since the absolute beginning of the scientific and humane study of the insane, or any study at all. Before that time, they were simply burnt, or manacled and starved, or thrown into solitary cells until they died. Nothing was learnt for them, or from them.

However, it so happens that, just as physiology is incalculably indebted to pathology, so the new psychology is becoming incalculably indebted to psychiatry—the study of the insane. Only disease of the thyroid gland could teach us what the healthy thyroid gland does for us; only disorder of certain parts and powers of the mind can teach us what they are worth to us, or even that they exist.

The Mystic's Visions as Diseases of the Subconscious Mind

The study of the insane, we said, gave science a new explanation of these phenomena. Instead of regarding them as simply fraudulent, we are inclined to look upon them as morbid; genuine, but morbid. The mystic's visions were visual hallucinations due to the cold and starvation with which he had disciplined himself; the voice which the prophet quoted as the voice of the Lord was merely an auditory hallucination, due to much brooding upon the nation's sins, and an intensely susceptible and "auditive" type of temperament and mental cast.

Beyond a doubt this newer explanation comprises within itself a large measure of truth. Many of these phenomena are due to disease of the subconscious mind, which their existence has helped orthodox science to recognise. It begins to be seen that the health of the subconscious mind is an essential part of any health, and that, in dealing with the problems of mental disease, the physician must recognise the subconscious mind, and try to reach it with "suggestions of healing," as we shall see more clearly when we study the phenomena of hypnotism. But is this all? Does the disease theory cover all that part of the ground for which the fraud theory was inadequate; or do there still remain facts which require a further theory still?

Evidence Needed that Psychical Beings Influence the Subconscious Mind

Such facts must be those which deal with what has been called "veridical" manifestations. If the "voice" reveals what no mortal mind could know, and if we can exclude chance and coincidence, then we have to ask whether the voice was not more than an hallucination. All turns upon this. When there is anything of the nature of a "revelation," when the communications purported to be made to and through the medium are such as no theory of fraud or

disease or chance can explain, we must accept the theory that some psychical being made them. Here, of course, is something which can be put to the test, and many people, for many years past, have been trying to test it. The quack "séances" of the past were plainly useless. If the "spirits" existed, and were responsible for what the "medium" uttered, then, as Huxley said, in his caustic and effective way, the evidence furnished "an additional argument against suicide;" if, after death, we are to be capable only of such rubbish, let us stay here as long as possible, with the prospect of eternal inanity in front of us.

from the dead. When Mr. F. W. H. Myers died, he left, sealed and secured, certain writings which were known to none but himself. He hoped that, after death, he might be able to get into communication with Mrs. Piper's subconscious mind, so that she might be able to recite the contents of these documents, wholly unknown to her, and so establish the fact that the surviving psyche of a dead man, remembering this life, could communicate with the living; or rather, the sheer, momentous fact that the psyche did survive. Unfortunately, the results of this experiment have been so dubious that we can only call them negative.

AN ARTIST'S CONCEPTION OF A VISION—"SPEAK, SPEAK," BY SIR JOHN MILLAIS

We require proof, such as science regards as proof in other fields of inquiry, that the phenomena displayed by the subconscious mind of the hypnotised medium—he or she is usually hypnotised, for the reason we have seen—are really due to the agency of the psychical beings to whom the medium, no doubt honestly in many cases, attributes them. We require evidence to convince us that Mrs. Piper, to name the most celebrated medium now living, is capable, while in the hypnotic state, of receiving communications from the unseen—for instance, The supposed communication did not correspond to the writings which Myers had left. The proof he hoped to be able to furnish to mankind after his death is still to seek.

Having gone so far, very many people will feel that further inquiry is going to be unprofitable, but he is a very presumptuous and even a treacherous man of science who would have no one devote himself to such studies. We know enough to know there is a great deal more to know. We may never find out what we desire, but we shall find many valuable things on the way.

SELF-POISONING BY FOOD

The Tragedy of the Prosperous Man who Shortens His Days by Indulgence

SIGNS OF AGE AND HOW TO MEET THEM

It is, of course, the hygiene of the mind at which we have been aiming in all the foregoing discussion of bodily health. That discussion was necessary for the sufficient reason that the brain is a physical structure and is the organ of the mind. In our discussion of exercise, alcohol, diet, ventilation, we were all the time concerned with the effect of such things, not upon the bones or muscles, but upon the brain and the mind. In the last chapter we endeavoured to trace the conditions of mental health in childhood and early adolescence. Now we have before us the problem of the adult; and the first fact we notice is that no sooner is man adult than he begins to grow old, at a less or greater pace.

In his recent book on the human body, Professor Arthur Keith gives us the most authoritative and modern statement of the fact expressed by Shakespeare in the "Seven Ages of Man." From birth onwards the body continues to change. There is no stationary period. No year passes and leaves us the same. As Dr. Keith says, the skin of the face and the muscles of expression that lie under it are the most accurate register of years. "Not one passes and leaves the skin just as it was; every year the tender, soft, suffused, velvety covering of babyhood moves one degree towards the dry, grey, wrinkled, and loose integument of the very aged." A complete human life is made up of two distinct periods, one marked by the ascendency of growth and the other by the slow assertion of decay. Where the first period ends, about the twenty-fifth year, *the other begins.*

These are the physiological facts which the hygienist has to reckon with; otherwise he will soon be mistakable for a charlatan, promising or assuming the impossible. But let him further note that the normal age-changes of the body do not progress with equal speed in all its parts. The elastic tissue of the skin and of the coats of the arteries is the first to age; hence the tell-tale nature of the skin, and the fact that the sprinter, for instance, begins to lose his speed after the twenty-fifth year or so. But the brain is at its best as the controller of muscular action between thirty and forty; so that the fine sprinter or long jumper of the twenties becomes the great batsman of a decade later. Yet, further, the brain is probably at its best as an organ of thought between forty and fifty—a great contrast to our assertion about the arteries and the power of making violent physical efforts.

Yet we do not all grow up, or grow old, at the same rate, and all mankind, and womankind no less, appeals to the hygienist for the maintenance or the restoration of youth. This is what the alchemists sought for so eagerly, an "Elixir of Youth," that should stay the advance of the Man with the Scythe. In recent years great attention has been paid to this subject, and many writers, such as Metchnikoff, Forel, and our own Sir Thomas Clouston, have contributed to our understanding, and even to our control, in some degree, of the problem.

It may fairly be said, against all these distinguished writers, that they fail fully to appraise the importance of natural differences in this respect, alike between species, races within a species, and individuals within a race. Longevity is largely a natural character, depending upon native constitution. Recent evidence is conclusive on this point. Thus, the purveyor of the modern substitutes for the elixir of youth will vastly increase his reputation if he selects his cases suitably. Let him reject subjects whose parents and grandparents died at an average age of forty, and choose those whose ancestral figure is twice as high. This will help him wonderfully.

The point here made is so far from recognition, even by many high medical authorities, and yet has been so clearly demonstrated by statistical study, notably by Professor Karl Pearson, that we might well consider it at much greater length. But if the reader will not estimate its importance by the small space we have devoted to it, we may proceed, merely citing the recent evidence which shows how much modern man, if he values length of days, has to be thankful for. The lowest extant race of men are the native Australians, of whom trustworthy observers state that at forty-two they show the same age-changes as appear in the average European of sixty-two. These great racial differences can be, and are, paralleled in the individuals of any race, and hygiene that claims to be scientific can no longer afford to ignore them. Its field for action remains, contracted, perhaps, but capable of more intensive cultivation.

The Inevitable Loss of Physical Efficiency as Men Grow Older

Let us consider the problem afresh, and, for the sake of order, let us first note the physical and, in the next chapter, the psychical factors which are concerned in accelerating or retarding the action of the normal and inevitable law by which every one of us is growing older every day.

Nothing is more conspicuous than the tendency for the body, in most cases, to become larger and heavier as youth departs. There are many and important exceptions, more or less real, but this is the general tendency. In part the expansion is not due to an increase of tissue. Thus, the dimensions of the chest tend slowly but surely to increase from year to year, not because the lungs are growing or developing in any true sense, but because their elastic tissue, upon which their power of recoil after inspiration depends, is becoming old, like the elastic tissue in the skin and the arterial coats. Hence the chest becomes slowly larger, and *less* efficient, because the lungs tend to remain in the expanded condition, and have thus less of that range of movement, between contraction and expansion, upon which their use depends. Physiological chemistry cannot yet tell us at all why our elastic tissue loses its youth so soon, nor can the hygienist confidently offer any advice on the subject.

But there is a very common tendency—not so invariable as the last—for the body to become larger and heavier also, by the sheer addition of fat. Many of us tend to grow stouter and older simultaneously. In part, perhaps, this may be called normal, or even healthy. It may be argued, for instance, that as the power of responding to cold by means of muscular activity slowly begins to fail, it is an advantage to have a thicker layer of heat-conserving fat upon the body. But, however that may be, no one can doubt that this accumulation of fat is too often excessive, and tends to become, beyond all question, morbid.

The Tendency of Obesity to Lower Men's Mental Activity

If this question of obesity were purely a bodily one, we should be going contrary to our principles in discussing it here, but it is not. Visible obesity is accompanied by the deposition of fat within the body-cavities, such as the abdomen and chest. It interferes, in time, with the action of the heart, and thus with the aeration of the brain. Hence it leads to lowered mental activity. The idleness of the obese person is not entirely due to the fact that he or she has a greater weight than other people to move about with a given amount of muscular tissue. It is also due in part to the fact that the bodily processes whereby the brain is supplied with pure, ventilated blood are interfered with. Hence the mind, as it were, begins to lose its youth, and that is where we are concerned. Exceptions there are, about which we know too little. There are people of active mind, much joy in life, and much usefulness who are undeniably stout. This seems to be their native peculiarity; and their case is distinct from that of the more ordinary type of person who grows fat as he grows older, and whose mental activity fails concurrently, as if he were suffering from a fatty degeneration of the mind.

The Typical "John Bull" as an Illustration of Physical Decadence

Our comparatively recent prosperity as a nation, dating from the great industrial expansion of the nineteenth century, gave us such ideas of *personal* prosperity as are natural for those who have hitherto never had enough to eat. Lazy stoutness typifies prosperity to them. The John Bull of the cartoonists and the posters is thus depicted as of "full habit," and we are taught by suggestion that a prosperous man of middle age should have such a contour. Yet, to the critical eye, John Bull's corporation, thus depicted, is a deformity, an objectionable sign of physical decadence, *usually* associated with mental sloth and incipient senility. The person presented by the cartoonists as typical of our national

prosperity must have the utmost difficulty in lacing his own boots, could not catch a bus, is evidently incapable of any kind of prolonged exertion, and almost certainly suffers from fatty infiltration of the heart. These are not signs of personal prosperity, though they may only too faithfully symbolise the state of a nation which is in mortal peril from luxury and success.

Really, we know that obesity is not healthy for mind and body—the exceptions being remembered. And so we employ a euphemism in discussing it. In the whole realm of life there are no two tissues more his muscle-cells, not least those of his heart, will degenerate and become replaced by lifeless oil, or fat, which cannot contract. So when we say that a man is putting on flesh, he is usually losing flesh, for flesh is muscle, and muscle goes when fat comes. The most notable and rare exceptions to this rule are the men who are likeliest to swim the Channel—men like Burgess, who have a highly developed muscular system, with plenty of warmth-conserving fat outside it. They have this exceptional natural endowment, no more to be acquired by most of us than blue eyes can be made brown.

THE SEVEN AGES OF MAN, AS PORTRAYED BY W. MULREADY, R.A.

contrasted than flesh and fat. Flesh is muscle, consisting of extremely active cells of living protoplasm; fat-cells contain almost no protoplasm, and instead of it are simply filled with lifeless oil. Fat-cells are scarcely more worthy to be called alive than an emulsion of cod-liver oil outside the body. We recognise this distinction between flesh and fat, while ignoring it, when we politely say that a man is "putting on flesh," but he is never doing anything of the sort when we say so. He is putting on fat; and if he continues the process he will very soon begin to replace flesh by fat, for

But the John Bull of our artists is in a state not of health but disease. He eats too much and works too little. His blood-pressure is too high, his arteries are hardening, his power of thought is becoming impaired. In due course he will have a "shock"—due to the bursting, inside his brain, of one of his degenerate and too tightly stretched arteries. If he recovers from it, and returns to his bad habits, he will soon have another, which will probably kill him. Or, as many men do nowadays, he may learn wisdom, and live on, in a more or less disabled state, for years after the first warning. The longer

he lives without a further hæmorrhage, the more does he demonstrate that the first should never, and would never, have occurred if he had taken proper care of himself. Middle-aged or elderly readers will find it more convenient to adopt, *before* the first shock, something like the rational mode of life which physicians impose, afterwards, upon such of their patients as survive this dangerous injury—accident we cannot call it.

Long ago a German writer pointed out that "the whole secret of prolonging one's life consists in doing nothing to shorten it." Our recent studies in heredity have shown how largely the possibilities of life are predetermined for each individual, but environment and behaviour will determine how much of the allotted span he shall enjoy. Any man whose ancestors lived to be octogenarians may commit suicide at any age, obviously, or subtly and unknowingly, as most of us do. No hygiene as yet definable will increase the allotted span of a man's life; but hygiene can increase, for practically all of us, the proportion of our allotted span that we shall attain to, and, no less, the proportion of it that we shall enjoy.

Our discussion, then, is not the prolongation of life, but the avoidance of the causes which shorten it. The distinction is real, though it makes no difference to the individual whom we enjoin. The first assertion to make is that, as our study of diet has indirectly suggested already, over-eating markedly, definitely, and with shocking frequency shortens life. Further, the man who is *not* obese need not be so confident that he, at any rate, does not exceed. He may be slowly poisoning himself to death and shortening his life, even though the excess he practises does not happen to show itself in obesity. His neighbour, with a natural tendency towards stoutness, may *not* be guilty of excess, appearances notwithstanding. The whole question is much too subtle to be settled by a mere weighing-machine.

Microscopic examination of coats of the arteries in the two cases is much more to the point than tailors' measurements of the coats they are concerned with. In the well-known saying, "A man is as old as his arteries," and, indeed, the saying is as completely true as any epigram can hope to be. One of the tragedies of the modern world is the failure of arteries, and of what depends upon them, among those who are most influential in the conduct of our affairs. It is a calamity not only for the individuals concerned, but for society at large, when the mental powers of the middle-aged and elderly, who govern us, fail prematurely. The elderly ought to govern, if they are also young in mind, simply because of the value of their experience. We have already seen at what age the brain reaches maturity as an instrument of thought; and that fact, coupled with the value of sheer experience as such, makes it clear that the elderly should have the power of government largely in their hands. Most of the great works in philosophy and political thought and science have been the achievements of the elderly *in years*.

JOHN BULL
From a cartoon by Sir F. C. Gould.

But we may be very sure that those elderly men, who have given us the great works of human thought—not of art and emotion, but of thought—were men with soft, young arteries—and "a man is as old as his arteries." Perhaps we should do better to say that a man is as old as his mind, and that a man's body is as old as his arteries. But the health of the arteries and the powers of the mind are closely connected. The great elderly men are, in effect, young men with the experience of old men. Such a man, with years of observation behind him, but arteries still supple, and a mind still supple too, can make the best of both ages. These are the men, well provided both with knowledge and mental capacity on the one hand, and power of standing physical strain on the other hand, who at any moment lead in the worlds of politics, business, or scientific inquiry. Microscopic inspection of their arteries at fifty would probably show no changes as compared with the average arteries of twenty-five.

It now seems practically certain that over-eating, quite apart altogether from the action of alcohol, is a leading cause of *premature* arterial degeneration, involving premature physical and mental degeneration generally. Mild poisons, contained in the surplus food, or derived from it, or prevented by it from making their normal escape from the body, or from being normally destroyed in it—we do not yet know the exact *modus operandi*—circulate in the blood-vessels, and produce a degeneration the consequences of which show themselves

in every organ of the body, and notably in the brain. Some suppose that the poisons cause the vessels to contract, and so induce a sort of overwork which leads to thickening and subsequent rigidity of the coats of the vessels. This arterio-sclerosis, or arterial hardening, is known by medical men to be one of the most important of all diseases, though the public hears little of it. It is one of the standing subjects for discussion at medical conferences, and research laboratories all over the world contain men who work at nothing else.

Arterial Hardening as a Most Serious Form of Physical Degeneration

Arterial hardening, and not merely the rate of the pulse, is one of the things which every medical student is taught to feel for when he puts his fingers on a patient's wrist. The body in which the arteries are hard is an old body, whatever the patient's age. The most lamentable thickening and hardening of the arteries may be found in childhood, where the blood has been poisoned by congenital syphilis. Infants thus infected look "old" at birth, and *are* old in this meaning of the word. Where the poisoning has this cause, the arterial wall thickens, until at last the passage for the blood is occluded. If and when this happens in the brain the consequences are of the gravest.

The commoner forms of arterial hardening, such as those which are now known to be associated with alcoholism *and* with overeating—teetotallers are not immune from physiological vice—usually lead to an irregular thickening of the arterial wall, which involves its weakening. Practically, all cases of apoplexy or shock are due to the rupture of such an artery. The weak place may have been present for some time, and then, perhaps without any obvious cause, the pressure of blood within the artery is raised, and the vessel is ruptured. But actually no man can burst a *healthy* artery from within.

Age a State of the Soul that is Not Measured by Time

No student of this subject can proceed far without discovering how subordinate is the place taken by mere time in the scale of factors of age and youth. These are both states of the soul. At all *temporal* ages this proposition may be illustrated. Professor Earl Barnes, a well-known student of education, has shown that, in many features, what he calls the "music-hall mind" is practically identical with the "twelve-year-old" mind. Adult possessors of the "music-hall mind" are mentally no more developed than children; and emotionally they may be very inferior to children, or to themselves as children, especially through the influence of sex upon them. But at the other end of life are met many old men and women who retain the optimism normal to healthy youth, and its avidity for new ideas, plus a nicer discrimination, a maturer judgment, and that "restless energy" which, as Goethe said, "alone proves the man." If we agree that a man is as old as his mind—that is to say, as old as his essential self—these elderly people are really still in their prime, and should properly be regarded as ageless.

Now, while it is certain that man's span of years is greatly increased beyond that of his remote simian ancestors, there are arguments which suggest that our span of active and happy years should be even longer than it usually is.

The Premature Character of the Vast Majority of Deaths After Sixty

The mentally alert centenarian should be a commonplace, and the octogenarian who can effectively criticise his juniors and add to his life's achievements, like Spencer, Kelvin, and Galton in the recent past, and Dr. Alfred Russel Wallace today, should be the rule rather than the rare exception. The vast majority of deaths, even after sixty years of age, are rightly to be regarded as premature; and even worse is the fact that, of many who live at these ages, the distinctively *human* life has almost expired. Something is far wrong when we hear so often the cry, "too old at forty." A creature that takes twenty-five years or so to reach maturity has no business to be too old at forty; there is no instance of such a proportion among other vertebrates. In the records of neuro-muscular skill, furnished by cricket and billiards, for instance, we find many men in the first rank who are close upon forty, and in not a few cases the man in question is actually at his best. When such a man begins to "go off," he should normally do so very slowly and almost imperceptibly. But these are the men who take care of themselves, and their slow loss of form is due to genuine growing old, and not the pseudo-senility which so many middle-aged men soon begin to illustrate.

The evidence is clear that longevity is, in part, a natural character, transmitted by inheritance. But no evidence yet exists which enables us to estimate the relative importance of this predisposition as against

the mode of life. There are many instances of long-lived families, some known, no doubt, to every reader in his own experience. But we commonly observe that longevity is associated with strict canons of life, temperance in all things from childhood upwards, and existence under highly favourable conditions. It is well known that women live longer, on the average, than men. This longevity is, in part, a sign and consequence of that superior vitality of the female sex which shows itself at all ages from infancy upwards. But we must remember that more men than women shorten their lives by indulgence in alcohol, tobacco, and food—just that indulgence which we fail to find in long-lived families. We do not know what would be the comparative longevity of the sexes under equal conditions of hygiene, environmental and personal.

If it be true that the most certain, constant, and accessible criterion, not of age as such, but of our position on the up and down of life, is the state of the arteries, it is plain that most of us spend our time upon trifles in this regard, while the weightier matters of the law of life go wholly unregarded.

The Mistaken Attention that is Devoted to Superficial Signs of Age

Too many people, not realising that the state of one's cutaneous elastic tissue is no criterion of real age, concern themselves with such things as crows'-feet and wrinkles, or with grey hair or baldness, which are all cutaneous matters, and are therefore insignificant. The senility that is only skin-deep is a very superficial affair, and everyone knows that it may co-exist with splendid vigour and skill of nerve and mind. As for grey hair—a much better sign of cutaneous senility than baldness—no one but the stupid employer takes that seriously, one would think. It matters little enough that a man has a senile skin if he has the soft arteries of health, the heart of a boy, and the mind of mature manhood withal.

As for the failure of the arteries, it seems plain that we too often dig our graves with our teeth, running to meet death half-way by a slow suicide which no one reprobates, but which is far more reprehensible than most of the suicides which we call disgraceful. The fact is that nearly all the changes in the body which students of disease have hitherto called degeneration are not so; they are the changes of intoxication. The changes in the consumptive lung were for centuries regarded as degenerative—the patient's tissues were supposed to go into a premature "decline." We now know that the case is one of poisoning, and we have identified the poisoner. Similarly, the high temperature of fever was supposed to cause disease changes in the body, but experiment has shown that high temperatures, in themselves, produce no such changes. It is the poison in the patient's blood that poisons his tissues, and also makes him hot.

The Difference Between Premature Senile Degeneration and Poisoned Tissues

Similarly, what used to be called "premature senile degeneration" of the arteries is nothing of the sort. It is chronic intoxication. Premature senility is known, but it is extremely rare. To these extraordinary cases Mr. Hastings Gilford, of Reading, gave the name, a few years ago, of progeria. The patient grows old in his teens, and may die at fifteen with all the characteristic symptoms of extreme old age. These astonishing cases are not understood; probably they have to do with misbehaviour of certain glands, somewhere or other. But they serve very clearly to show that we have talked nonsense when we have used the phrase "premature senility" hitherto, where we should have recognised a totally different thing intoxication—and should have dealt with that.

Several of the poisons which cause arterial disease have been already referred to. Lead is a conspicuously powerful though rare addition to their number. But the poisons need not necessarily be of external origin. They may be made within the body, and they will then be proportionately more difficult to control.

Some of the Real Causes of Increasing Arterial Rigidity

Sometimes they may be derived from accumulated food, which is undergoing too slow changes of fermentation in the bowel. It is thus generally believed that chronic constipation in early middle life and thereafter hastens or initiates arteral failure. It is also asserted that violent and persistent exercise not only raises the pressure of the blood and so compels the arteries to become thickened beyond their capacity for maintenance, but also leads to the formation of muscular fatigue—products which are definitely toxic.

In a lecture at the Royal Institution a few years ago, Sir Clifford Allbutt gave a notable warning to the man whose blood-pressure remains persistently too high. He will soon grow "old," and will do well

to consult a physician. The best sort of doctor for him will be one of years and experience—but soft arteries. The symptoms on account of which a middle-aged man may suspect his blood-pressure, and should consult such a physician, may be fatigue, headache, lessened joy in life, lessened power of work, failure of the faculty of attention, and sometimes insomnia. Obviously these are vague and general but familiar symptoms.

Simple Measures of Health for Warding Off Quick-Coming Age

Nevertheless, they are the early symptoms of arterial rigidity, supervening upon a prolonged period of too high blood-pressure. The doctor who is consulted by such a patient, and who finds, from the state of the pulse, and from the accentuation of the second of the two sounds produced by the heart-beat, that the blood-pressure *is* too high, and even that the arteries are beginning to show signs of poisoning, will recommend a number of simple and commonplace measures of general health, such as we have been discussing for many months past in this section of POPULAR SCIENCE. He will stop alcohol altogether, and may do the same for coffee, which directly raises the blood-pressure, or even for tea. He will go far to make milk the staple of his patient's diet, for, while milk nourishes, it does not poison. The quantity of meat consumed must be severely cut down, owing to the stimulant effect of the extractives of meat upon the coats of the arteries, which are already too tense. Violent exercise, which raises the blood-pressure, must be forbidden, but moderate exercise is valuable, notably for its service towards the activity of the bowel. Indeed, the doctor will pay special attention to the prevention of constipation, which is very likely to be present.

Regulation of Diet Less Formidable than Threatened Disease

The diet must be carefully regulated accordingly, and this is the more necessary as cows' milk tends to constipate the human adult. Cream is of value in this connection. The patient should keep the skin fairly warm and active, remembering that the sweat-glands help to rid his body of poisonous rubbish. The quantity of water drunk by the patient, in one form or another, should, as a rule, be considerably increased, for, as we have already seen, water facilitates the action of the body-ferments which destroy poisons, it directly dilutes and so lessens the hurtfulness of poisons, by its mere presence, and it greatly helps the body to rid itself of poisons by dissolving them and carrying them away with it through the kidneys or the skin.

Simple directions like this may wear a very formidable aspect for some men, who may be inclined to say that the remedy is worse than the disease. They know the worst of the remedy, but they do not know the worst of the disease. The few wise are wise in time; the many will not be troubled, until at last the intoxication of the arteries in the kidneys leads to Bright's disease, and that of the arteries in the brain leads to an apoplectic shock. Then the remedy is no longer thought worse than the disease; but irreparable harm has been done. The reader is here strongly counselled to take care that he belongs to the few who are sensible with themselves in prosperous middle age, and do not presume unduly upon the resources and the recuperative powers of maturity.

A Possible Explanation of the Good Effects of Metchnikoff's Sour-Milk Diet

As for sour milk, we cannot say that enough is yet known to permit of any dogmatic conclusions. The theory of its use appears to be sound, whether or not it is really the case that the number of centenarians in Bulgaria is so abnormally high as Professor Metchnikoff supposed. The sour milk, taken by us, as by the Bulgarians, may certainly interfere, if it gets the chance, with the activity of microbes in the bowel, which would otherwise produce poisons, thereafter absorbed and intoxicating the arteries and the tissues in general. But it may be that the lactic acid of the milk is all neutralised and absorbed long before it reaches the latter part of the bowel, where the objectionable microbes are supposed to occur. If this be so, the usefulness of sour milk may be smaller than we hoped. Probably most of the good which has followed its use has been due simply to the partial substitution of milk for other forms of diet, which were formerly poisoning the patient. Until further notice the reader will be well advised to follow the quite commonplace and familiar directions of these pages if he wishes to prolong maturity of mind and body as long as possible. The psychical factors of the question remain for our study. No reader who has ever observed the influence of bad news or worry upon the skin and muscles of the face will question that there are psychical factors of this question, no less important than any others.

THE FIGHT AGAINST FIRE—HOW MAN CONTROLS ONE ELEMENT TO CONQUER ANOTHER

A CONFLAGRATION IN A TIMBER-YARD, WHERE FIERCE HEAT AND BLINDING

THE FIGHT AGAINST FIRE

One of the Dangers that Increases with the Advance of Civilisation

FLANNELETTE AND CELLULOID RISKS

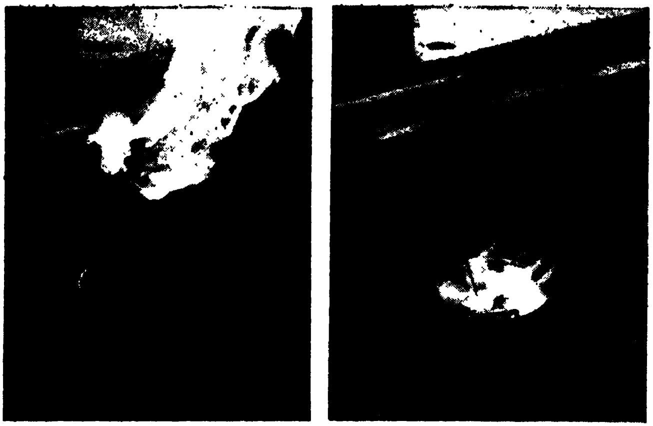
With the exception of the microbes of infectious disease, there is no danger that increases with the increase of urban civilisation like the danger from fire. It is reckoned that the loss of property from fire in Europe alone every year now amounts to over £50,000,000, and the annual loss of human lives throughout the world from the same cause is very great. In less than three hundred years London was three times almost entirely destroyed by fire. The first of these periodic conflagrations occurred after the Norman Conquest. Less than a hundred and fifty years later the City was again burnt almost to the ground, and in 1666 the Great Fire broke out in a wooden house in Pudding Lane, and, raging for three days, destroyed 13,200 houses and 92 churches and chapels. Estimated in modern money-values, the loss of property approached that of the entire annual conflagrations throughout the world.

No doubt, formidable conflagrations of this kind in ancient times were largely due to the fact that wood was used in a general way for building the greater part of ordinary dwelling-houses. In Russia, where timber-built houses are still very common, it is said that the entire erections throughout the country are practically destroyed in every seven years. In the United States and Canada, the cheapness and convenience of forest timber also lead to many towns and villages being built of wood, with the result that conflagrations not uncommonly make a complete clearance.

In many settled lands of ancient civilisation, the general use of brick and stone for building purposes has somewhat diminished the danger from fire. But in other ways this danger has been increased. Each advance in the chief domestic comforts and in the principal industrial uses of power has augmented the risk of fire. Cheap matches, oil-lamps, flannelette clothing, celluloid combs and other articles, the use of gas in lighting and cooking, and the employment of electrical power for illumination, have all combined to make the modern brick dwelling-places of the people almost as dangerous as the timber-built homes of their ancestors. In mills, factories, and workshops, sparks from machinery, short-circuiting of electric currents, over-heating of furnaces, boilers, and steam-pipes, and many other accidents connected with the use of high energies, bring about serious fires. Not very long ago the annual loss of property through fire in our country alone amounted to £17,000,000. But now, in spite of the daily increase of the buildings around our great towns, and the erection of more factories and other places where power machinery is employed, the yearly wastage from fire is only £12,000,000. This marks a very considerable progress in the control of the immense energy of heat by which our civilisation is run.

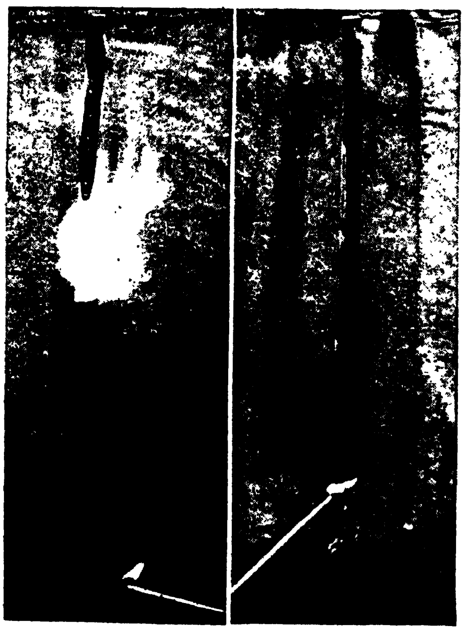
It was after the great Cripplegate fire of 1897 that our nation became distinguished in the new science of controlling its sources of heat power. The British Fire Prevention Committee was then founded, without any kind of State aid; and engineers, architects, men of science, public officials, and municipal corporations joined this remarkable private organisation, which now has five hundred members, who give their services freely in the noble work of diminishing the general danger to life and property through fires. Even their out-of-pocket expenses are not reimbursed to them; and they have now spent over £12,000 of their private moneys in undertaking all sorts of tests and experiments of materials and inventions likely to diminish the inflammability of the homes and working-places of the people. It is

since they broadly inaugurated the science of fire-prevention that our country has saved £5,000,000 a year in property, and some thousands of men, women, and children from the most dreadful of deaths. Their indirect influence has been quite as important as the actual work they have done and are still doing. They have provoked a widespread interest in all methods of fire-prevention. They have excited the conscience of manufacturers of highly inflammable goods; and this has led to some of our best chemists being charged with the task of inventing flannelette clothing and celluloid articles that will resist fire.



CELLULOID CONTINUING TO BLAZE WHEN IMMERSED IN A BUCKET OF WATER

Of all the new fire-dangers of modern civilisation, flannelette is probably the most serious. It was introduced into the English market in 1885. It is nothing more than cotton with a raised surface, but it owes its popularity to the fact that it is warm and pleasant to the touch, and capable of being produced in colours so as to be hardly distinguishable from wool. Above all, it wears well, and it can be produced and sold at extraordinarily low prices. Owing to these qualities, it has come largely into use as a material for clothing among all classes of persons; and among the poor it may be said that women and children almost universally wear flannelette. But owing to the process by which the surface of the cotton is raised, the cloth converted into flannelette is much more liable to catch fire than an ordinary cotton fabric; and cotton fabrics, again, are far more easily ignited than flannel.



CELLULOID AND NON-INFLAMMABLE FILMS

This test by the British Fire Prevention Committee shows the immediate result of placing a match against these two films.

So many and so widespread were the deaths from fire caused by the use of flannelette that in 1908 the Home Secretary appointed a Committee to inquire into the flannelette danger. The Committee was assisted by Sir T. E. Thorpe, the late Principal of the Government Laboratories, and by members of the British Fire Prevention Committee. Pieces of various samples of flannelette were suspended vertically above a small spirit-lamp, the flame of which was brought just for an instant into contact with the surface of the fabric. In another test, a nightgown or dressing-gown was placed on a frame, in much the same position as it would assume when worn by a human being. Then the flame of the spirit-lamp was allowed to touch it. It was found that the flame travelled rapidly upwards and extended to the right and left, with the result that it reached the top of the garment in about thirty seconds, and the whole or the greater part of it was consumed in a minute.

So it was clear that a woman or child whose skirt or dressing-gown of flannelette came into contact with fire would suffer serious injury, and probably be burnt to death, unless prompt and effective measures were taken. The worst cases occurred with the cheapest flannelette, with a long and a loose

raised nap. In the better sort of material, with a shorter fibre and a closer texture, momentary contact with the flame usually produced only local scorching on the surface. It was on the cheap and popular material that the fire spread with deadly rapidity.

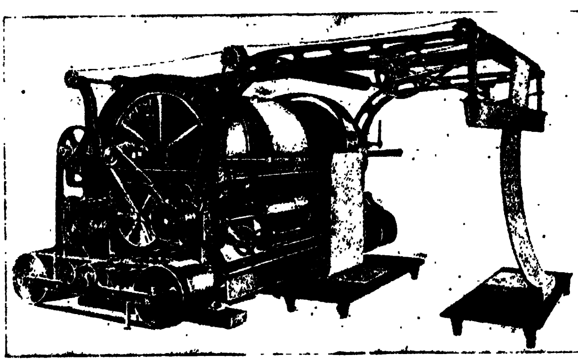
is not far wrong, and it is clear the chances of recovery from burns are materially affected by the use of the fabric."

The only point of light in the gloomy report which the Committee submitted to Mr. Winston Churchill, in August, 1910, was a reference to a new kind of flannelette

A CONTRAST IN THE INFLAMMABILITY OF NON-FLAM AND ORDINARY FLANNELETTE

The three photographs on the left show Non-Flam before the test at the British Fire Prevention Committee's station, at 30 seconds after lighting, and at 120 seconds after; the three on the right show ordinary flannelette before the test, at 30 seconds, and at 60 seconds.

Few figures in regard to deaths and serious injuries from flaming flannelette were before the Committee. But they found that, in the months of October and November, 1909, and January, 1910, the deaths in which flannelette played a part were no less than 176. And the Statistical Officer of the Home Office noted the fact that, in reference to the ages and sexes of the persons dying from burns, there was "an abrupt falling off at about the age when male children cease to be dressed in petticoats." Of course, there are many contributory causes to the accidents. Carelessness in regard to matches, candles, and open fires, and the absence of fireguards, and the practice of leaving children without any competent person to look after them, are mentioned by the Committee. But they state in conclusion: "The common opinion attributing to flannelette a large share of the blame



THE RAISING MACHINE USED IN THE CONVERSION OF COTTON CLOTH INTO NON-FLAM

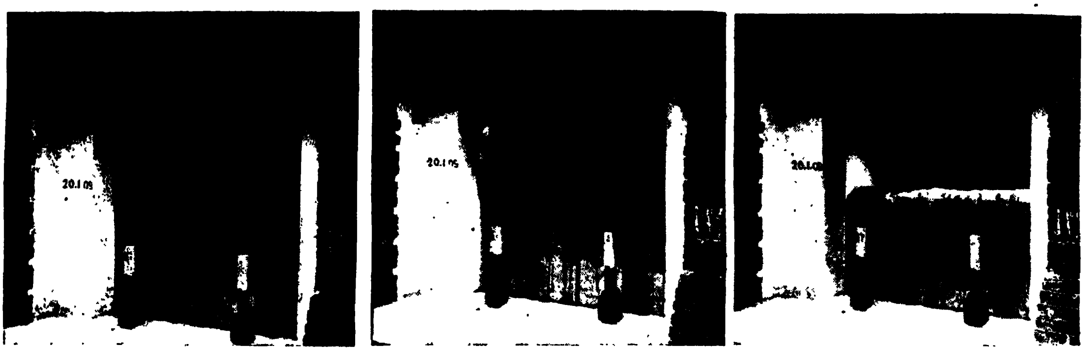
that Dr. W. H. Perkin, of Manchester University, was then working on. Some time before the Committee was appointed, a Manchester firm of flannelette makers had asked Dr. Perkin to devise for them an unburnable kind of flannelette. After carefully looking into the matter, Dr. Perkin consented to do what he could. He found that the problem was a difficult one from many points of view. It was clear that the process, to be successful, must not damage the feel or durability of the cloth, or cause it to go damp, as many chemicals do; and it must not make it dusty.

Moreover, it must not affect the colours of the design of the cloth; and the fire-resisting had to be permanent. That is to say, washing the garment fifty times or more must not remove the fire-resisting qualities. Furthermore, in order to give it a wide application, the process had to be cheap.

In short, the flannelette had to be treated in such a way that it acquired practically the properties of wool, which for all ordinary purposes may be taken as a standard of safe material. Some idea of the difficulties of the problem that the famous chemist hoped to solve will be gathered from the fact that upwards of ten thousand separate burning tests were made before he succeeded in converting the cheap cotton fabric into something as good as a woollen material.

Flannelette is made from calico by means of a series of revolving rollers, covered with a vast number of small pieces of sharp steel wire. These tear up the surface, and the calico is passed over the rollers again and again until the required amount of nap has been raised. The nap is a fluff of minute cotton fibres resembling a thin layer of cotton-wool. This cotton-wool imprisons a covering of air, which acts as a non-conductor of the heat of the body where the material is used as clothing. Genuine flannel made of wool does the same thing. So, if the cheap cotton fabric could be made non-inflammable, it would become a safe and very serviceable article of warm wear. Seeing that the essence of the problem was to obtain something that would not dissolve in the water in the wash-tub, or remove by mechanical rubbing, Dr. Perkin did not begin by coating the surface of the flannelette with any substance known to resist fire.

Several chemicals of this sort were used as a fire-resisting paint for wood. Alum, water-glass mixed with chalk, and green vitriol have been employed for the purpose. But none of them was applicable to flannelette. Some washed out almost at the first rubbing, some made the material dusty, and others were too violent a poison for impregnating clothing with. What was needed was something that would be completely absorbed by the cotton fibre, and so fixed there that washings would not remove it. Almost every variety of salt was tested by Dr. Perkin and his assistant, Mr. Samuel Bradbury. And after some years of vain and laborious experiments, they began to doubt if a salt existed that was resistent to soap-and-water. They obtained their first gleam of light on tabulating the results of all their seemingly useless work.



A PHOTOGRAPHIC RECORD OF A FIRE TEST WITH A LARGE TIN-CLAD ARMOURED SLIDING DOOR
These three pictures are from a series taken at the testing station of the British Fire Prevention Committee, and show the resistance of a door after 95 minutes' and 125 minutes' exposure to a temperature of 1700 deg., and its collapse after 147 minutes.

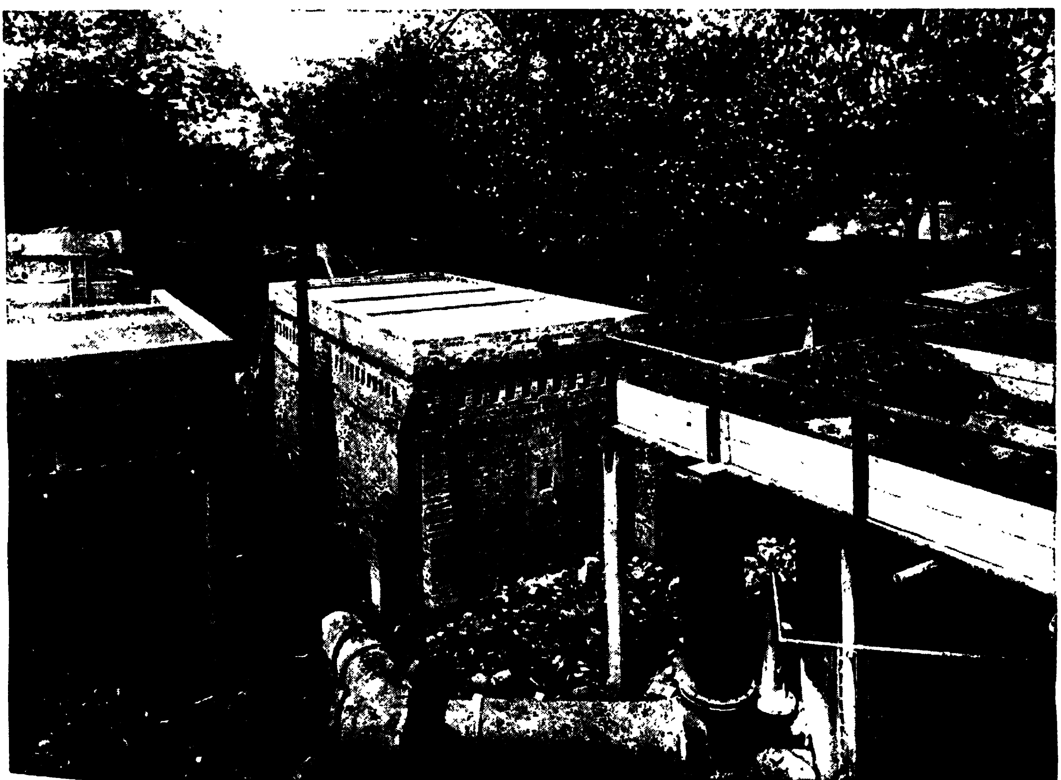
For the table showed that certain combinations of salts of tin were more lasting than many of the harder salts. In particular, it was found that stannates formed by oxidised tin treated with soda were absorbed by the cotton fibre. In one experiment it was noticed that a piece of flannelette that was first saturated with this preparation of tin, and dried, and afterwards treated with a solution of zinc chloride, was quite non-inflammable. Unfortunately, the greater part of the fire-resisting substances was lost after repeated washings. Then another chemical, known as stannous chloride, was used for the second treatment. The results were excellent. No amount of washing could remove the combined chemicals. Dr. Perkin thought he had at last solved the problem, but again he was disappointed. For the chloride used in conjunction with the tin preparation possessed a great bleaching power. No colours could be applied to the material treated with it.

However, the path to the crowning discovery had now been discovered; and it was not long before Dr. Perkin obtained a fire-resisting flannelette that could be dyed and washed and scrubbed without rendering it inflammable. The process was at first costly, by reason of the amount of tin

HOW SCIENCE MEASURES FIRE'S EFFECTS

A TEST WITH FIFTY GALLONS OF PETROL

FIRE-RESISTING GLAZING AFTER 80 MINUTES

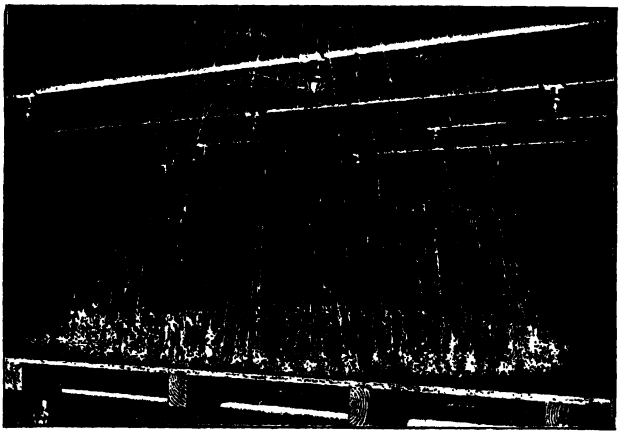


THE REGENT'S PARK TESTING STATION OF THE BRITISH FIRE PREVENTION COMMITTEE, SHOWING THE THREE CHAMBERS AND A CORNER OF THE GAS-PRODUCER WITH ITS GAS-MAIN

wasted in the manufacture. But this wastage was finally prevented; and though tin now fetches about £210 a ton, the non-inflammable flannelette treated with it does not cost more than a penny a yard above the ordinary cheap and deadly quality. Moreover, this treatment so increases the strength and durability of the material that the little extra cost a yard is well recovered by the longer life of the material.

One of the advantages of the process is that it can be applied to any cotton fabric. It is especially valuable in connection with muslin. For this material is often used for dresses which, by reason of their flimsy nature, are highly inflammable. Muslin is particularly dangerous on the stage, where many terrible fires have arisen. Another field of manufacture in which the process may be used with great advantage is in connection with lace curtains. These are among the most dangerous things in a house; a lace curtain blowing in a draught near a light or a fire has brought about many a disaster. All these perils can now be prevented by the "Non-Flam" process of the great Manchester chemist.

As now manufactured, the flannelette is run through a solution of sodium stannate—a preparation of tin and soda—in such a manner that it becomes thoroughly soaked. It is squeezed to remove the excess of the liquid chemicals, and then passed over heated copper drums, in order thoroughly to dry it. After this, it is run through a bath of ammonium sulphate, and again squeezed and dried. It is quite possible for anyone to make flannelette fire-resisting at home in this way, but the unavoidable waste of material makes the experiment expensive on a small scale. It can only be done at a cost of a penny a yard at the works. After the double bath, the flannelette is passed through water to remove the sodium sulphate which has formed on it, in addition to the precipitated tin preparation which is now fixed in the fibres. When dry, the material, which is unspoiled in appearance, undergoes the ordinary processes of finishing.



THE GRINNELL AUTOMATIC SPRINKLER IN ACTION

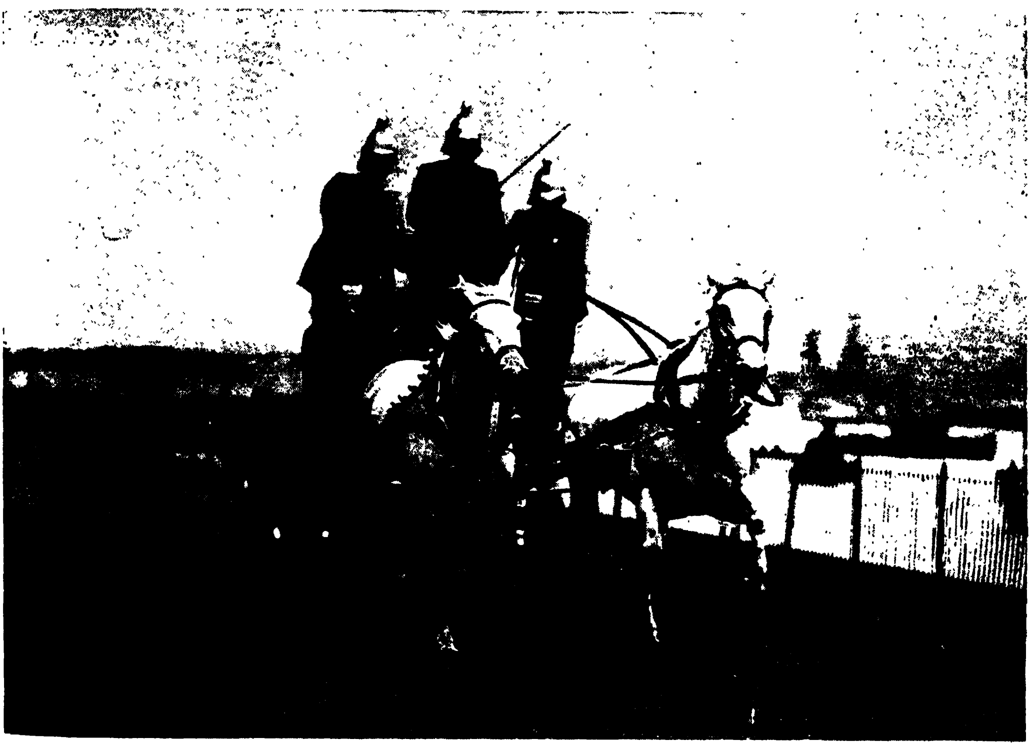
There can be no doubt that Dr. Perkin's process has now been developed to a point of practical perfection. No amount of washing with hot soap-and-water will remove the fire-resisting agent. The property of resisting flame lasts as long as the material itself endures. Dr. Perkin himself reckons that the oxide of tin has not only been absorbed by the cotton fibre, but has entered into a special combination with the cellulose of the cotton, producing a compound which cannot be broken down by the action of the weak alkali of the soap. The treatment has no effect on the delicate colours now generally used in the manufacture of flannelette and other cotton goods; and very careful experiments have proved that the tin compound in the fibre has not the slightest deleterious action on a delicate skin. Moreover, the presence of the oxide of tin gives the cloth a softer and fuller feel than that of the original flannelette; and the most unexpected result of all is the fact that the material has an increased strength of 20 per cent. after undergoing the process.

Thus the flannelette danger has now been completely overcome. All there remains to do is to bring the Non-Flam process to the knowledge of every member of the community. This could be done most quickly and thoroughly by an Act of legislation forbidding the sale of inflammable flannelette. But the Committee did not see their way to recommend a measure of this kind. At the time when they were holding their inquiry Dr. Perkin's process had not been completely worked out. Now, however, this has been done so that it can be applied cheaply and effectually, some steps ought to be taken to make it a general practice. We would suggest that all flannelette manufacturers should be allowed to use the process on payment of a small royalty. If this could be arranged, we do not think that any man would have so hard a conscience as to go on manufacturing the cheapest, most dangerous, and least durable of flannelettes, knowing that he was tempting women of the poorer classes to risk the

lives of their children, and their own lives, to save an immediate penny in the yard. The security and the increase of wearing strength can now be obtained at a cost of 1½d. or 2d. extra on a child's garment. This is surely so small an insurance against an awful death by fire that the very poorest mother can afford to pay it.

Next to the flannelette danger, the peril of celluloid is of grave importance. It is at present extremely dangerous to manufacture, and, as the Coroners' Committee pointed out, when used for articles of dress, or for combs and such things, it is probably just as likely as cheap flannelette to cause accidents among persons to whose mind the inflammability of the material has not been brought by some ocular demonstration. As is fairly well known, celluloid is manufactured from cotton waste treated with nitric acid. That is to say, it is prepared in the same way as gun-cotton. It is, in fact, gun-cotton of a weaker sort, dissolved into a fluid state and mixed with camphor to prevent it from exploding. The combination of the cellulose of cotton with the nitric groups of chemicals introduces so much oxygen that the new compound has all the elements for complete combustion, while ordinary combustion depends on the gradual supply from without of the oxygen of the air to the burning body. It is the explosive nature of the cellulose nitrates which imparts so considerable a danger to the manufacture and use of celluloid or xylonite. The celluloid film used with an electric arc or some other powerful light in kinematography is the worst of all celluloid risks, and it has ended in several disasters.

For this reason Messrs. Cross and Bevan, the great English cellulose chemists, have for some time being trying to discover a substitute for the perilous nitrates employed in the celluloid industries. After much research and experiments, they found that a strong preparation of vinegar distilled from wood could be used instead of the dangerous nitric acid. Recently another chemist, Lederer, has worked out a more economical process of employing wood-vinegar in the making of celluloid. He used wood pulp, that costs only one-third of the price of cotton, and he treats it with a mixture of acetic acid and oily chemical vinegar, to which a small quantity of sulphuric acid is added. This strong preparation attacks the fibres of the wool, and dissolves them into a very sticky liquid, which is purified by the simple process of washing it in water.



THE DASH OF THE FIRE-FIGHTERS IN ANSWER TO A CALL

The vinegary oil known as acetic anhydride is, however, rather costly. So while the ordinary cellulose nitrate can be bought in the open market at from 1s. to 2s. a pound, the safer cellulose acetates are at least three times as dear. But more economical processes are now being worked out in connection with the acetic methods of manufacture, and the difficulties in the way of the general commercial success of the non-inflammable product are constantly growing smaller. So we may happily expect that in a short time there will be a complete revolution in the celluloid industry, similar to that which has taken place in the manufacture of flannelette. Important assistance may be obtained from the group of now famous English chemists who have accomplished the synthetic creation of indiarubber from maize, for one of the chief by-products of synthetic rubber is a colourless liquid known as acetone. This is usually obtained, in conjunction with wood-vinegar, by strongly heating wood in an iron still. As soon as it is made in larger and cheaper quantities from maize it will help to bring down the price of the non-inflammable varieties of celluloid. So the second new fire-danger in modern civilisation will be avoided.

Returning to the larger and older problems of fire-prevention, we will now consider what advances have been made in building private dwelling-houses and large industrial edifices so as to lessen all fire risks. The proper construction of hearths and furnaces, flues and chimneys, has of course an important bearing on the problem. And we are glad to say that many of our builders are taking a keen interest in this vital side in their craft. That fewer of our houses now burn down is due partly to their better planning and building. But too much wood is still used. We shall never get a real fireproof house until Portland cement is mixed with sand and strengthened with steel bars, and used instead of timber in house-building. A very small quantity of wood, in a building constructed almost entirely of non-combustible material, will furnish enough heat to destroy it. Ceilings made of laths are specially dangerous. They should be run on wire netting. And if wooden joists are used for nailing the floor-planks to, they should be protected by asbestos boards or slag-wool.

FIRE-FLOATS PLAYING UPON A BURNING CARGO STEAMER

Armoured concrete beams, however, would be safer. We hope that in time it will be possible to pour a concrete flooring at as cheap a rate as a really well-made and

EFFECTS OF FIRE ON STEEL STRUCTURES

A FIREPROOF SAFE AMONG DEBRIS

A STEEL PILLAR BENT BY FIRE

THE TWISTING OF STEEL GIRDERS IN A BIG FIRE IN NEW YORK

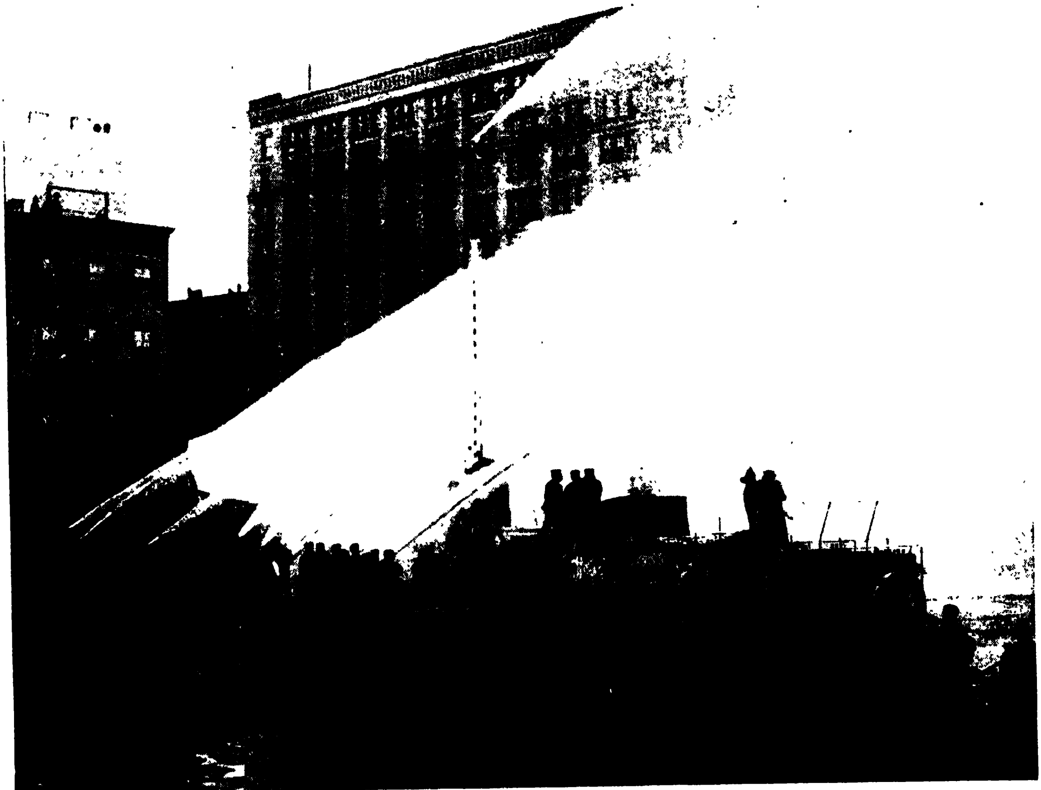
The top right-hand picture is by permission of the British Fire Prevention Committee That on page 3966 is by permission of Messrs. Mather & Platt

properly protected wooden flooring can be laid down. It is the disappearance of the old-fashioned heavy oaken beams, and the use of lighter and cheaper joists, which have weakened the modern brick house in its resistance to fire. And the laths used for ceilings have added to the danger. Timber is now so dear that it is impossible to return to the old-fashioned use of wooden beams. On the other hand, the employment of girders of iron or steel is not to be commended. It is now well known that the use of naked iron or steel work in building is extremely dangerous in the case of fire. The metal loses practically all its strength when exposed to great heat. Even when the steel frame is completely enclosed, it is not safe from fire.

The Mutual Life Insurance Company building in San Francisco was constructed in 1892 with the greatest care. The laying up and filling of joints in brick, stone, and terra cotta was as perfect as possible, and the steelwork was entirely protected. Yet this modern building, eight storeys high, did not survive the conflagration following on the great earthquake that broke all the electric wires and opened the gas-pipes of the metropolis of the Californian coast. Since this terrible disaster there have been several outbreaks of fire in factories and other large modern buildings constructed on a steelwork frame. In every case, where a great amount of heat was produced, the steel buckled, and gave way in a manner that no sound piece of genuine and strong brick or stone work would have done. The American architects have had more experience than our architects in steel framework. They were the originators of the skyscraper, and they are now taking the lead in discarding their own invention. For a series of dreadful conflagrations has taught them that no steelwork can be effectually protected against fire by a covering of brick, stone, or terra cotta.

FORTY PARIS FIREMEN AT CLIMBING DRILL
From the Paris Red Book of the British Fire Prevention Committee.

It would be well if we could at once profit by their experience, and follow them immediately in the new and safer method of constructing large buildings which they have worked out. As we have already remarked in POPULAR SCIENCE, the concrete house made by means of wooden or metal moulds is the house of the future. It is absolutely fireproof, for practically no woodwork is used in it. A beautiful, fine-grained surface of exquisitely coloured cement and sand is obtained in cupboards, dressers, wardrobes, and other things usually made of wood. Wood is becoming dear as well as dangerous in house construction. It is wanted for making paper, chemicals, celluloid, silk, railway sleepers, telegraph poles, and small pieces of furniture. Portland cement, on



THE HOSE-PIPES AND WATER-TOWERS THAT ARE FED DIRECT FROM THE WATER-MAINS

THE TRIAL OF THE FORCE OF WATER PUMPED THROUGH NEW YORK MAINS DURING A FIRE

the other hand, has grown cheaper with increasing use. It is made out of river mud and chalk hills, and things that exist in more abundance than mankind will ever require. So the general use of the fireproof concrete formed from it would help to conserve the timber resources of the world, and enable men to make better use of the wealth of the forests.

Until the fireproof city is the common feature of our civilisation, we shall have to rely, for the prevention of conflagrations, on the various inventions for extinguishing fires. Pre-eminent among the means of putting out flames is the automatic sprinkler now largely used in factories. A system of water-pipes connected with the city mains, or with a tank in a tower, runs through the ceilings of every room. On the upper side of the pipe, sprinkler-heads are attached. They have usually a half-inch outlet, kept closed by a valve held in place by levers. The levers are fastened with a fusible solder, that melts at about 160 degrees Fahr. As soon as a fire starts in any room, the warm air rises to the ceiling, and the solder melts. The valve is swept away by the water pressure. The half-inch stream bursts out, and, striking against a deflector, it is spread in a shower. In ordinary circumstances, a fire is extinguished by the automatic action of from one to four sprinklers.

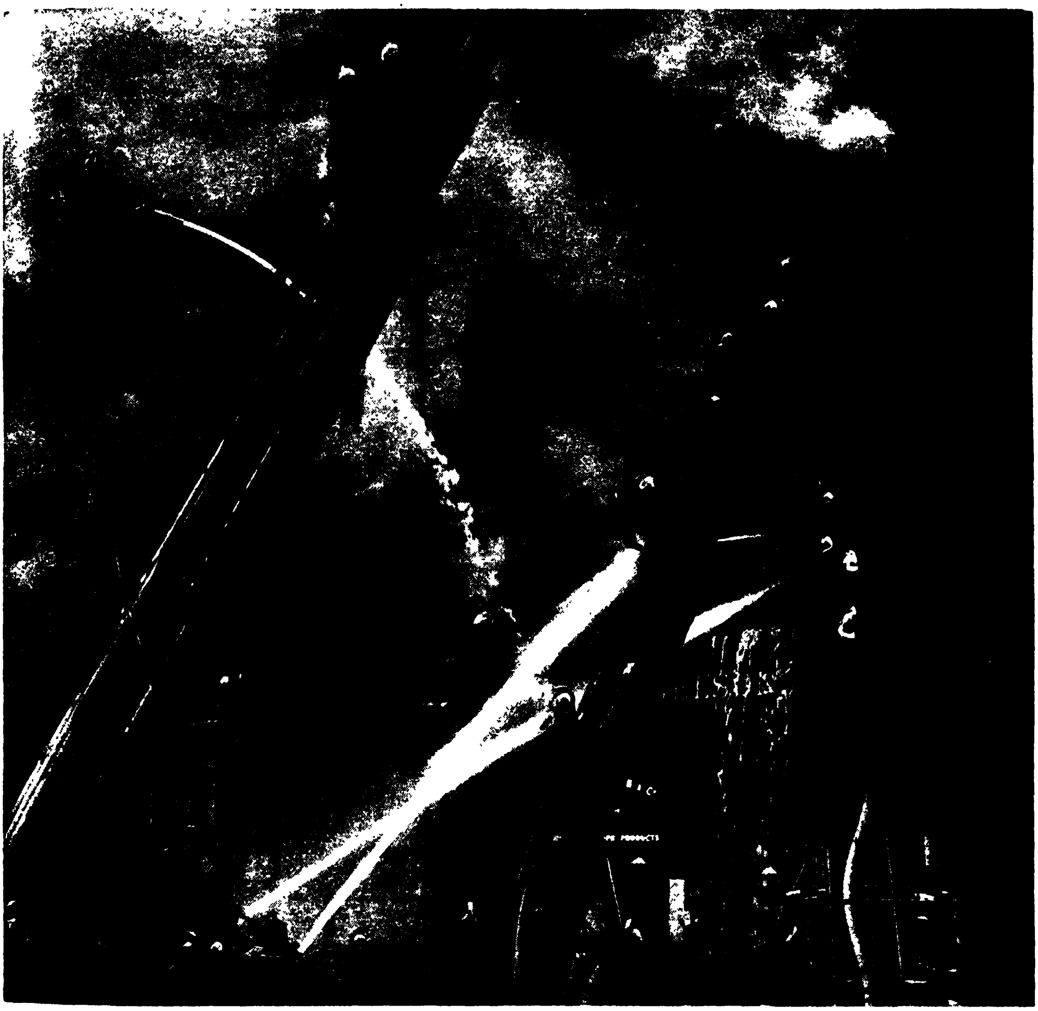
THE COMPRESSED-AIR SMOKE-HELMET
From the Paris Red Book of the British Fire Prevention Committee.

But in extreme cases the heat may provoke all the sprinklers in a room into operation. Every sprinkler guards from 80 to 100 feet of area. It is on duty every hour in the day, and every day in the year. It opens just where the fire is, and it works in smoke and poisonous fumes where no man could live. It was first introduced in 1875, and it took many laborious experiments to perfect it. For the automatic sprinkler must withstand corrosion and atmospheric changes, and remain in repose for years, and yet respond in thirty seconds to a change of temperature. Employed on a large scale by the American Association of Factories, it helped to reduce their loss from fires from 33·7 in 1860, to 6·9 in 1910; and it is now widely used in British factories.

Sometimes the automatic fire-alarm is employed in American buildings in place of the automatic sprinkler. It consists of a heat-detector connected with an electric circuit. When the temperature reaches a certain point the detector comes into play, and closes the circuit, thereby setting in operation an ordinary fire-alarm telegraph apparatus. It can be made to give a local alarm by ringing a gong or bell, at the same time as it rings up the central fire-station. One form of automatic alarm is the thermostatic cable, that may be fixed in the wall or ceiling of a room, or temporarily trailed over floors or piles of goods in factories and warehouses. In such a cable, one of the electric wires is coated with an expansive metal, wrapped with a yielding insulator, and further surrounded with a series of spirally arranged fine wires. When the coating on the inner wire is expanded by heat, it is brought into contact with the outer wires. The current of electricity passes into these fine wires, with a result that the steady electric flow from the cable to the main office is interrupted. This causes a bell or gong to ring in the office of the Fire Alarm Company, and the force of the Company is usually on its way to the fire about one minute after the automatic alarm is given.

Sometimes, instead of the cable, a small round box with a perforated lid is used. Inside is a bent spring, composed of an inner strip of steel welded to an outer strip of brass. The action depends upon the fact that brass expands more than steel under the influence of heat. As only one end of the spring is fixed, the heat causes the free end to bend inwards until it closes an electric circuit. These instruments are usually placed at intervals of about fifteen feet upon the ceiling of the room, and the heat from a very small fire quickly causes them to telegraph the exact position of the outbreak.

Everybody living in a large town knows the appearance of the signal-boxes of the ordinary fire-alarm system, out of which inventors have developed the Automatic Alarm Service. In case of fire, one goes up to the red signal-box at a street corner, breaks the glass front, and pulls the alarm. But in some places in the United States the mechanism of the public fire-alarm is so valuable information to the firemen. But the handcuff is too large to be concealed under a coat-sleeve; and if a practical joke is intended the sorry jester can easily be distinguished, for he has no means of removing his badge of alarm. On the other hand, if the alarm is well founded, the signaller is honourably freed from the handcuff as soon as the fire-engine arrives.



THE LONDON FIRE BRIGADE AT WORK IN THE HEART OF THE METROPOLIS

arranged that, when a signal is sent, a large steel handcuff slips over the wrist of the person giving the alarm. This has been arranged to prevent malicious fools from playing practical jokes on the fire brigade, and calling the men and engines out when there was no need. The handcuff does not imprison the alarmer to the signal-box, as it is often found he is the person most interested in staying the fire, and he can give

But in some New York districts, and in parts of other large American cities, the fire-engine is no longer used. Instead of running a steam-pump to the site of the conflagration, and attaching it to a water-pipe in the street, and pumping the water to the high pressure necessary to obtain a powerful stream, the pumping is done at a big central station. The firemen only bring their hose and water-towers, escapes, and

ladders, on a motor vehicle. They have no need to keep steam up night and day for the purpose of pumping water into a flaming building. Let us assume a fire has broken out in New York, in the business district in which the new central pumping system is used. The alarm is transmitted in the usual way, from the street-box or from an automatic fire-alarm telegraph, to headquarters. From here it is sent out to various fire-houses in the city, including the two high-pressure pumping-stations. At these stations there is always on duty an operator at a telephone switch-board. He can put the station into communication not only with the scene of fire, but with headquarters, and with other stations. Special telephones in metal boxes are distributed close to all the hydrants throughout the high-pressure district. They connect direct to the station, by means of a special night and day service, maintained by the telephone company. In front of the operator is a large board, containing the numbers and situations of the various alarm-boxes throughout the district, and those to which his own station responds immediately are indicated in red. The alarm comes in over a regular circuit; the gong sounds the appropriate number, which is registered by perforation on a tape, on which a clock also prints the time. If the alarm is one for the station, the operator immediately grasps the lever of a marine telegraph, and the signals to start are sounded, and shown on a large indicator on the wall. The pumping crew at once spring to their places, the chief engineer at the switchboard, and the oilers and mechanics at their appointed positions.

THE RESCUE OF TWO WOMEN FROM A FIRE IN FLEET STREET, LONDON

From the switchboard everything can be controlled and regulated. The current is switched on to the powerful motors, and the ponderous pumps are soon revolving. Another switch opens the electrically controlled valves that work the water-supply while recording it. And under the eyes of the chief engineer are other meters and indicators. Every fire does not require the flood of water that can be set in motion from the pumping-station. The standing order is to start one pump, regulating the pressure at the outlet to one to five pounds. The next order must come from the chief of the fire department at the scene of the fire, and it may be a call over the telephone to increase both the water-supply and the pressure, or it may be a command to shut down the pumps, as the fire is not serious.

The scene within the station when the pumps are in operation is not one of extraordinary activity. There is no more bustle and excitement than in a well-appointed power-plant. For the electrical control of the chief engineer is so complete that he does not need to leave his position at the switchboard. With an ear open for orders, and an eye on his meters and indicators, he commands the entire situation. Driven by the great motor-pumps, the strong, swift stream of water rushes along the pipes to the hydrant. There it enters

the hose fixed by the firemen, and spouts, if necessary, to a great height into the flaming, crackling, smoking building.

When all the pumps at the central station are working their hardest, if a greater quantity of water is still needed, the other hydrants down the street are connected with long lines of hose that bring the soaring flood to the spot where it can best be used. The new system is naturally somewhat expensive to instal, and it is at present employed only in certain parts of the city. But the convenience of having always at hand, at the scene of every possible fire, an overwhelming flood of water at high pressure does away with the costly upkeep of a large number of fire-engines, in which steam has to be kept up night and day. In the central pumping-stations the machinery has merely to be kept in perfect order. It only works when actually required; and, by using motor-pumps controlled by electricity, the water can be set moving through the pipes the instant that an alarm is given. Of course, a false alarm would entail considerable expense for fuel, besides putting all the pumping crew to great inconvenience. This is why the handcuffing public fire-alarm is very useful.

We shall probably have to wait until the electric age of modern civilisation before every room in all the houses of a city is protected with some kind of automatic fire-alarm. Meanwhile, the automatic sprinkler is the most efficient by far of private defences against fire. Many authorities are disinclined to place much reliance on the ordinary portable, chemical extinguishers. For the claim that the chemical ingredients are in themselves greatly effective in quenching flames is disputed. Plenty of ready water and an alert watchman might be as well. A system of automatic sprinklers would be better. On the other hand, water is of no avail in putting out the flames of paraffin, petrol, benzine, and other inflammable liquids. For the lighter fluids float upon it, and continue to burn. Now, however, a foam made of a solution of bicarbonate of soda and liquorice has been used with success. The tough foam is lighter than the flaming liquids, and floats upon them, and it is full of bubbles of carbon dioxide—a gas that does not support combustion. The foam is produced from a small steel cylinder, or, in larger quantities, from a covered bucket and a connecting hose. In one test, a mass of flaming benzine, in an iron tank thirty feet in diameter, was extinguished in three and a half minutes.

THE DENSE CLOUDS OF SMOKE FROM A FIRE AT AN OILWORKS

BRINGING THE OLD WORLD TO LIGHT—HOW THE DEAD PAST FAILS TO BURY ITS DEAD

ONE OF THE LATEST DISCOVERIES BY THE EXCAVATORS OF POMPEII—A CANTEEN, OR WINE BAR, WITH ALL ITS FITTINGS AND UTENSILS INTACT

HISTORY UNDER THE EARTH

The Wonderful Story of Excavation and Its Revelation of the Life of the Past

DIGGING UP VANISHED CIVILISATIONS

THE spade is sometimes mightier than the pen. A short time ago the story of mankind was reckoned to extend over a period of less than six thousand years. Not until a few adventurous men of science began, towards the middle of the nineteenth century, to dig up history in the deserts of the Orient were the curtains of myth and legend flung aside, revealing a strange and almost terrifying vista of human development, stretching backward over a million years.

A Frenchman, Boucher de Perthes, was the founder of the new science of excavating the story of mankind. He worked in 1839 at a sand-pit by a river in Picardy. There he discovered rough tools of flint, buried beside the bones of the woolly rhinoceros and other strange animals of the primitive world. He took his finds to Paris, but his countrymen merely laughed at him, and refused to draw conclusions from the evidence he placed under their eyes. It was not until Darwin approached the problem from another direction that a couple of Englishmen, Prestwich and Evans, also excavated the Picardy sand-pits and, in 1858, completely confirmed the extraordinary discoveries of Perthes.

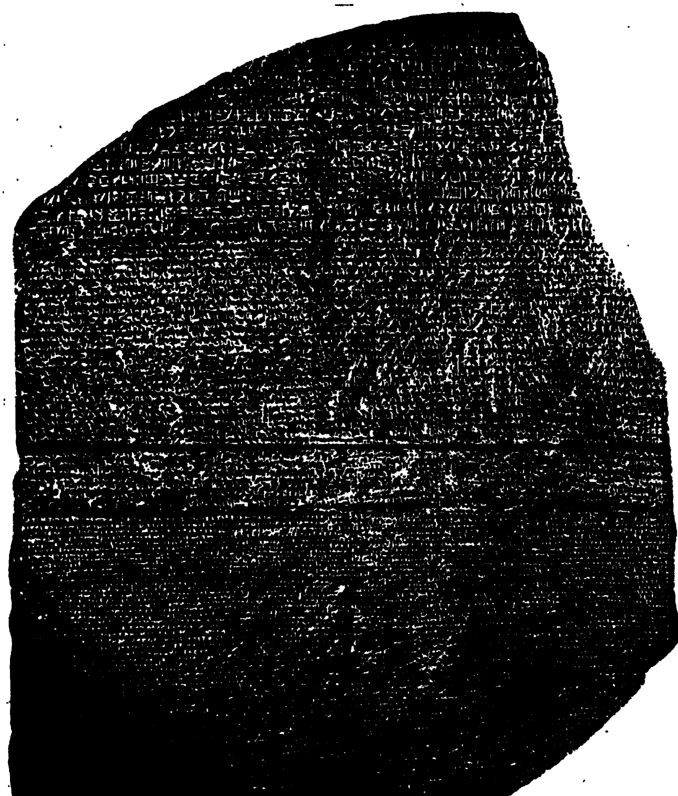
By this time the new method of writing history with a spade had been admirably developed by a band of roving Englishmen in the wildernesses of Mesopotamia and Persia. At the peril of their lives they mapped out the countries and determined the sites of the buried civilisations, studied the ways of life of the warlike tribes of Bedouins, and collected or copied some of the mysterious inscriptions still visible on bricks and sculptured slabs scattered about the deserts. Chief among the men who brought about the resurrection of a long series of perished civilisations were Sir Henry C. Rawlinson and Sir Austen Henry Layard. When they arrived in Mesopotamia it was a region of desolation, over which there still seemed to hang the maledictions of the great Hebrew prophets. Babylon and Nineveh, the mightiest cities of the earth, each 199 square miles in area, protected by walls 90 feet thick and 342 feet high, with a hundred gates and 250 towers, enclosing immense palaces, towering temples, and hanging gardens, had vanished like a dream of the night. In the springtime the wandering Bedouin pastured his herds on the grassy slopes that were once kingly palaces.

Boars and hyenas, jackals and wolves, infested the jungles that were anciently the most fertile of cultivated lands. Half-naked swamp-dwellers, their bodies almost black from constant exposure to the tropical sun, inhabited the desolate region that was the Garden of Eden ten thousand years ago, the tradition of whose extraordinary fertility descended from its earliest cultivators to the Babylonians and Assyrians and Israelites. The modern inhabitants of Eden sleep at night in filthy huts of reeds and mats; by day, in long, pointed boats of woven reeds, they skim over the flood of waters, catching fish with a spear. On the edge of the inundations they cultivate a little barley and rice, living in constant fear of the marauding Arabs, who descend upon them in winter and plunder and murder them. The innumerable canals, by means of which the earliest civilisers turned the reedy marshland and barren desert into a source of life and joy and wealth to every village and field, are now choked up with rubbish and earth. In autumn and winter Babylonia is a desert of sand; in spring and summer it is almost a continuous marsh—the desert of the sea that Isaiah prophesied it would become.

Three mighty races once dwelt in glory and power and gladness in this region.

First came the Sumerians, apparently a people akin to the ancestors of the modern Turks. Mighty in genius and originality, they quickly developed the arts of civilisation, and, extending their dominion on the Persian Gulf to the Mediterranean, they built up the first great empire of which we have any record. They were followed by a Semitic race from Arabia which, mingling with other stocks, established the Babylonian Empire. A further immigration of Semitic races from Arabia produced the Assyrian type in the northern part of Babylonia. Mingling with these three chief strains were other invading stocks, some of whom seem to have been akin to the types that have spread through Europe. These invaders built up civilisations and empires of their own about the upper reaches of the two great rivers of Babylonia. But all the works of their hands are also buried in the drifting dust of the desert and the uncurbed, spreading waters of the great streams.

Fierce, lean, hunger - driven wanderers of the wilderness pitch their black tents amid the wastes where Sumerian and Babylonian, Assyrian, Hittite, and Egyptian fought for the dominion of the ancient world. Ninety years ago no one was able to tell what language these ancient races spoke. Except, indeed, in the case of the Egyptians, some of whose monuments were visible above the sand of the desert, no one knew what signs they used in writing, what manner of men they were, and what they had contributed to the heritage of mankind.



THE ROSETTA STONE, THAT REVEALED THE HIEROGLYPHICS

There were a few legends and a few traditions recorded in Scriptural and classical literature, but these were either too fragmentary or too mythical to enable us to trace the story of the earliest civilisations. German scholars especially became extravagantly critical of both Greek and Hebrew traditions of the early ages of culture; and when the work of excavating the deserts was begun there was a widespread inclination to dismiss every figure in an ancient tale as a solar myth or some other incarnation of the more obvious phenomena of Nature.

When, in 1822, Champollion solved the mystery of the Egyptian hieroglyphics, with the help of the Rosetta Stone, on which one of the late Pharaohs had had a decree inscribed in the sacred script, the common script, and also in the Greek alphabet, the secrets of the visible ruins of the civilisation of Egypt were well on the way to be revealed. But as there was a good deal of sun-worship apparent in Egyptian religion, this only gave new zest to those students of the mythological school who were bent on reducing every great traditional figure of the past into a solar myth. Even the earliest kings of Egypt, of whom no contemporary monument could be discovered, were regarded as astronomical characters. It is only since Professor Flinders Petrie dug out of the desert near Abydos the actual portrait of a ruler more ancient than those of legend that we have got down to a prehistoric people with a totemistic worship of jackals and other animals.

In Mesopotamia and Southern Persia it was long before the languages of the ancient civilisations were discovered. But this exceedingly difficult work was at last accomplished by Rawlinson. At the age of twenty-three he was sent to Persia to help in drilling the Shah's troops, and by a happy chance some of his time was spent close to a great rock at the foot of the ancient highway from Babylon to Media. The rock stood 1700 feet high, and on the face of it Darius, the king of kings, had engraved a huge cuneiform inscription of his victory over a usurper. The writing was five hundred feet above the plain, and at an admirable linguist, with keen insight and immense learning. Layard was a masterful and energetic excavator, the most effective collector of material who ever lived. By working together, these remarkable men raised their country to the foremost position in the new science. Layard was in trouble when he floated down on a raft on the Tigris to see Rawlinson. He had set out in 1839 on a wild and adventurous ride from Turkey to India. Growing tired of studying law in the office of a London solicitor, he intended to travel overland to India and obtain a Civil Service appointment in Ceylon. But on reaching the spot

THE REMOVAL OF ONE OF THE WINGED BULLS EXCAVATED AT NINEVEH BY SIR A. H. LAYARD

considerable risk Rawlinson climbed up to it and took a copy. It was written in three languages, Persian, Susian, and Babylonian; and by studying the Persian text for many years Rawlinson was at last able to make out the mysterious Babylonian signs. He gave up a first-rate Indian appointment in order to reside at Baghdad as the British Political Agent for Turkish Arabia; and there, on Christmas Day, 1845, another English adventurer, Austen Henry Layard, came to see him. Their meeting was the most important event in the resurrection of the vanished civilisations of the Orient. From it dates all our full and intimate knowledge of the most ancient cultures of Asia.

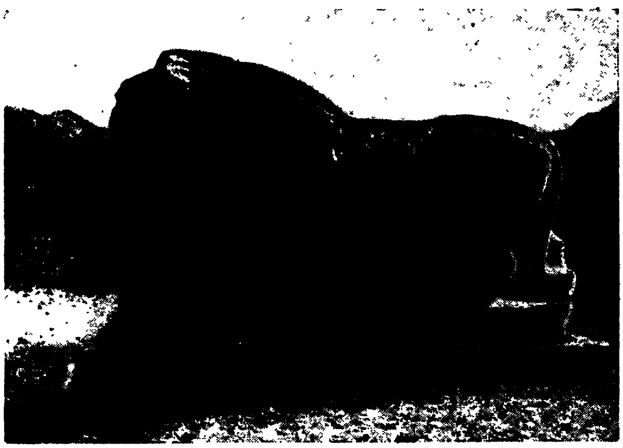
Each was strongest where the other was weakest. Rawlinson was a classical scholar,

on the Tigris where Nineveh once stood he changed his plans.

Ever since reading the "Arabian Nights" in his childhood, he had longed for a life of adventure in the East, and, having arrived at the desolate scene of his dreams, he gave up all idea of making his way in the modern world, and wandered in search of adventure among the tribes of the wilderness. He was robbed, he was often in peril of losing his life, and he had at last nothing left but the horse he rode on, and the knowledge of Oriental ways and tongues stored up in his strong and masterful mind. When his fortunes were at the worst, he resolved on carrying out a plan he had conceived at Nineveh. Riding hot-foot to Constantinople, he induced the British Ambassador,

to whom he had rendered some political services, to give him sixty pounds. Travelling night and day, he came back to Nineveh, and hired some men, and began to drive a trench at a spot which he had carefully studied.

The fact was that the English, who had been exploring and mapping out Mesopotamia for many years, were in danger of losing all the fruit of their labour to the French. Some inscribed bricks had been picked up and sent to London; and when the French Government heard of them, in 1842, they selected a man of science, with a knowledge of Arabic, P. E. Botta, and despatched him as their Consul to Nineveh, with funds for excavating the site. This was two years after Layard's first stay on the Tigris. When he came back after his adventures in Persia, he found the Frenchman actually beginning the work which he himself had only dreamt of doing. Yet he generously helped his rival in surveying the land and finding the most likely position for making discoveries.



A MARBLE LION UNEARTHED AT HINDIEH, BABYLONIA, IN RECENT YEARS

But, as soon as an attempt was made to drive a trench, the people of the country and their Turkish Governor stopped the digging. The people had strange superstitions about the buried city, and they were afraid that horrible ghosts and monsters, imprisoned beneath the earth, would be set free by the excavations, and attack them. The Turkish Governor was convinced that the Frenchman had come to dig up the fabulous wealth of ancient kings; and though he did not care to search for the legendary treasure himself, perhaps from superstitious motives, he refused to allow a foreign infidel to seek for it. So Botta was compelled to start his trenches in another direction, in which he only found some broken pieces of sculpture and fragments of inscriptions.

He had dug for three months without lighting on a single document in a perfect state, when an Arabian dyer from the village of Khorsabad, five miles away, chanced to stop and look at the work of excavation. He asked one of the native workmen what he was digging for. "Old bricks like this," said the workman, lifting up one of the broken, crumbling pieces. "Why, I have built my ovens of those old things!" said the dyer. "There is a big hill of them close to my village." Botta at first would not believe it, but his workmen went themselves to Khorsabad and brought back some of the inscribed bricks, and the French excavator, in March, 1843, began to work on the new site. It was the palace of King Sargon of Assyria, that had been destroyed by fire. By running trenches through it, there were exposed to the daylight statues of gigantic winged bulls, and magnificent reliefs illustrating the life in peace and war of the great bygone race, before whom the nations of Asia had trembled.

A LION FOUND BY SIR A. H. LAYARD IN THE PALACE OF ASSUR-NASIR-PAL, KING OF ASSYRIA, B.C. 885-860

All this was achieved in the face of extraordinary difficulties. The Arabs refused to work, no matter what money was offered to them, and Botta had to engage

three hundred Christian refugees to do the digging. Then the Turkish Governor, after throwing some of the workmen into prison, sent a band of soldiers to Khorsabad and stopped all the work, on the pretext that Botta's trenches were the beginnings of a system of fortification that was designed as a French military station for the subjugation of the country. The matter became at last an important political affair, and the French Government had to bring pressure to bear upon the Sublime Porte in order that Botta should continue his excavations. But in 1846 a man-of-war, despatched for the purpose to Mesopotamia, returned to France with a cargo of Assyrian antiquities, and the first great exposition of the monuments of a forgotten civilisation was held in the spacious halls of the Louvre.

The French, however, in spite of the enterprise of their Government, were not to have things all their own way. For Layard had returned in the winter of 1845 with the intention of excavating Nineveh in spite of the opposition of the natives and the Pasha. Fitting out a small raft, he floated down the Tigris, on the pretence of searching for wild boars to hunt. After going a short distance he moored his raft among the river reeds and began to search for wild boars with a spade! So wide and sure was the knowledge he had gained in the years he had spent wandering about the sites of buried cities that by a few hours' work, on the first day of his excavation, he discovered two Assyrian palaces. On hearing the news the Turkish Pasha at once sent some troops to stop Layard, as he had stopped Botta. But the Englishman was of a different character from the Frenchman. He was a born master of men, and by sheer force of personality he managed to get the soldiers, sent to stop him, to drive new trenches for him. In a short time they uncovered a pair of huge winged bulls, two winged lions, and a human figure nine feet high in the middle of the mound.

A WINGED MAN-HEADED LION FOUND BY SIR A. H. LAYARD IN THE PALACE OF ASSUR-NASIR-PAL

The people then rose up against the foreign infidel who was releasing all the horrible monsters which the wise men of old had imprisoned in the depths of the earth. One morning the excavator was slowly proceeding to the trenches, when two wild Bedouin riders came galloping towards him as fast as their mares would carry them. "Hasten, O Bey!" they shouted. "Hasten to the diggers! They have found Nimrod himself. Wallah, it is wonderful, but it is true! We have seen him with our own eyes. There is no God but God!" Without further words they fled to their tents, and when Layard reached the trenches he saw that his workmen had uncovered the enormous human head of one of the winged lions that now adorn the Assyrian galleries of the British Museum. But the native who cleared away the earth flung down his tools in terror when he saw the face of the monster, and ran away, yelling as he passed through the bazaar of the town that Nimrod had appeared. This confirmed the worst fears of the people. They were now certain that Layard had succeeded in his evil design of setting loose

upon the country the mighty and terrible spirits of ancient times. The excavator was compelled to discontinue his work. For, in addition to the grave personal risk he was running, he only found two men willing to remain in his service. One of them was a Chaldean Christian, Hormuzd Rassam, a name of high renown in the subsequent history of Assyrian and Babylonian discoveries

But Layard was never beaten. Besides having the whole population against him, he was now troubled by the intrigues of the French excavator, who was anxious to drive him from Nineveh In answer to the Frenchman, Layard turned to the mound that Botta had vainly worked at, and, trenching it in the right direction, found it was a palace more ancient than that of Nimrod. He discovered the library of the Assyrian king known to the Greeks as Sardanapalus, and thus provided Rawlinson with a splendid amount of materials for studying the literature and life and religion of one of the least known of the great nations of antiquity. Layard afterwards went from Nineveh to Babylon, and recovered the records of the older empire of Mesopotamia. But he was greatly disappointed at the small support he received from his own countrymen when the first shipload of the strange and mighty monuments he had dug up were presented to the British Museum, and after labouring for some years longer amid the Eastern deserts he returned to England, and Rawlinson took over the task of directing the excavations.

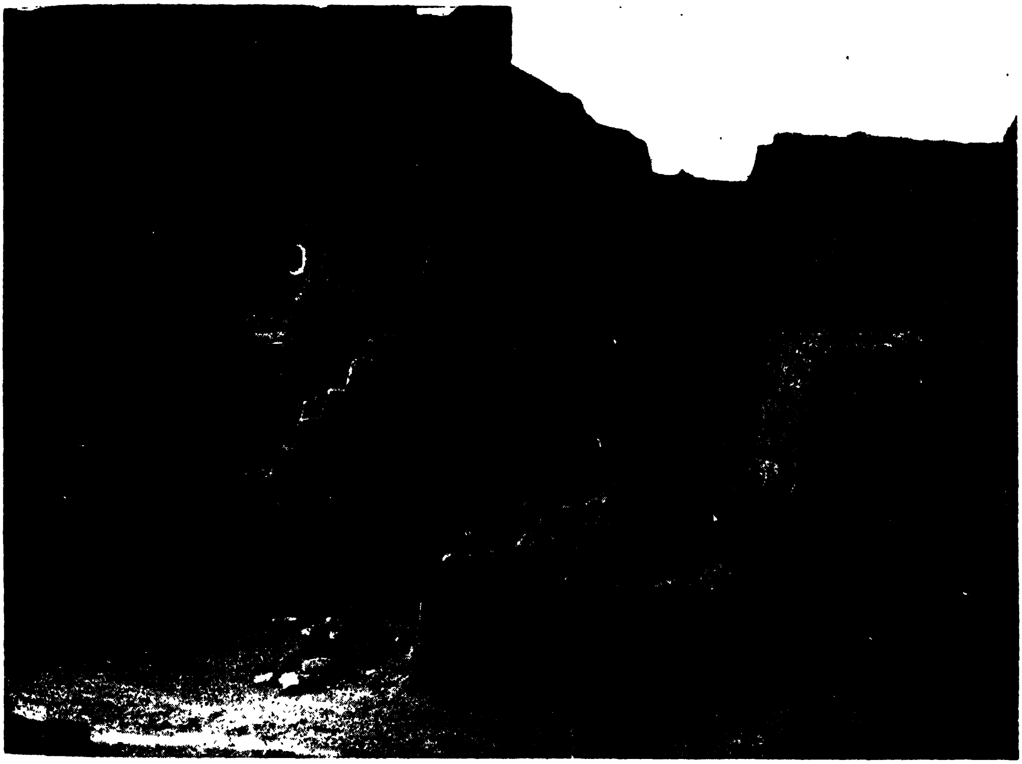
Then Hormuzd Rassam, the Chaldean Christian whom Layard had trained, was appointed chief excavator by the British Museum authorities. He had much of Layard's curious instinctive gift for planning trenches leading to discoveries of the highest importance. His work ranks next to that of his master. His grand achievement was the discovery of one of the earliest centres of civilisation in the world at an unimportant spot some thirty miles away from Babylon. Going behind both the Assyrians and the Babylonians, he reached at Nippur the mysterious Turkish race of Sumerians who converted the alluvial plain between the Tigris and the Euphrates into the Garden of Eden.

EXCAVATORS AT WORK AT QUERRISH, IN BABYLONIA

The seaport of this primitive civilisation was Eridu, which is now a hundred and thirty miles from the sea. It is reckoned it must have taken six thousand years for the river silt to landlock the sea-town in

this extraordinary manner. We must also allow some thousands of years for the development of the fine culture of the Sumerians, who had a notable literature, a marvellous system of agriculture, and several mighty and crowded cities. But some new discoveries recently made at Susa, to the east of the Tigris, seem to indicate that even the Sumerian civilisation was not the earliest. A French excavator, J. de Morgan, who has been working since 1897 at Susa, has dug eighty feet through layers of various civilisations before arriving at the primitive pottery and flint tools of the New Stone Age. Just above this is a more developed culture, with stone vases and seals, engraved with the figures of animals and indications of huts and crude bricks. Then a layer of cinders tells of the disaster that overwhelmed this primitive civilisation in the massacre of the inhabitants and the burning of their dwellings.

So at this early period, to which it is impossible to assign even an approximate date, Susa was destroyed by foreign invaders, and the pillagers installed themselves in the place of the murdered natives. A new civilisation appears with some extraordinary qualities. On cylinders of green enamelled paste there are moulded reliefs of lion-headed and bull-headed giants engaged in the sport of taming lions and bulls. Alabaster vases have also been found decorated with sculptures of ducks, pigs, fish, and squatting monkeys. But the most remarkable find of De Morgan is a series of texts, some inscribed on bone cylinders and others on clay tablets. They represent the earliest stage of cuneiform writing, afterwards developed in Babylonia and Assyria. But they cannot be read as yet, as the system on which they are constructed is different from that of the primitive Sumerians who originated the Babylonian culture.



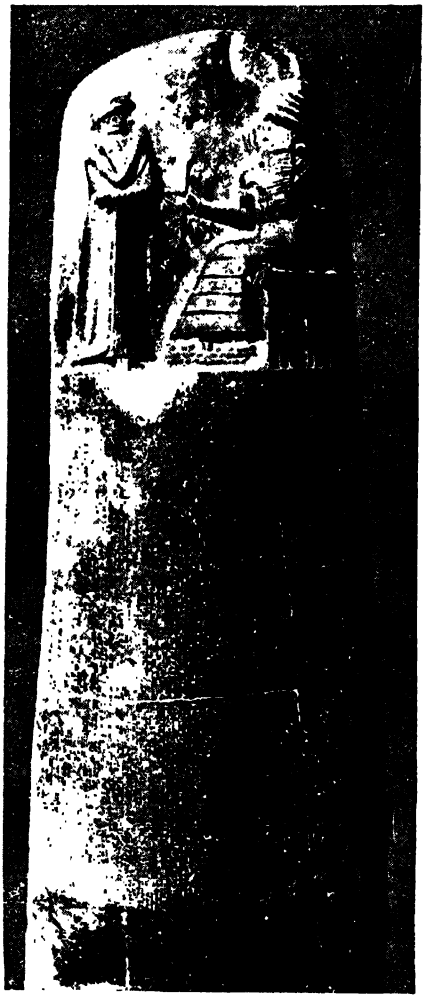
ONE OF THE MOST ANCIENT SACRED BUILDINGS—THE TEMPLE OF BEL, AT NIPPUR, BABYLONIA

The signs used at Susa are of such remote antiquity that it is quite possible that the cuneiform way of writing was invented by the Susian invaders. Moreover, the writing is done with a neatness and certainty indicating long practice. There are no errors or roughnesses of work such as would be the result of early attempts and experiments. But this mysterious literature also disappears in a catastrophe, and, amid the confused ruins above its remains, a series of new texts appear,

written in an Arabian dialect. The marauders of the desert had flung themselves upon the fruitful and well-watered region of which Susa was the capital.

In course of time Susa became a great empire, and its kings conquered Mesopotamia. A wealth of material has been unearthed by De Morgan concerning the fortunes of the Susian kingdom from the reign of Ur-iti-Adad in B.C. 3750 to the destruction of the city by the Assyrian Sardanapalus in B.C. 647. Susa was full of treasures won from the Babylonians, and the chief object of the Assyrian king was to recover these spoils of war. But, happily, he overlooked a huge block of stone which the Susians had taken, some thousands of years before, from the Holy City of the Babylonians. De Morgan excavated this stone, and it has proved to be the most valuable of all the documents of Babylonian civilisation.

The whole surface is covered with close, fine writing engraved with exquisite precision, and in the space at the top is a carving of a god taking a stylus from a king to write down the divine laws of the country. The king is Hammurabi, referred to in the Bible as the contemporary of Abraham. The writing on the stone is his wonderful code of laws that reveals a hitherto unimaginable height and thoroughness of culture among the early Babylonians. It is the most ancient code of laws in the world, and, in conjunction with the general literature of the country, it seems to show that the Israelites in after times were borrowers rather than originators. It is doubtful if even the monotheism which they developed was an authentic inspiration of their own. For movements towards the idea of a single Divine Ruler of the universe have been found clearly expressed in Egypt, at a time before Moses probably lived.

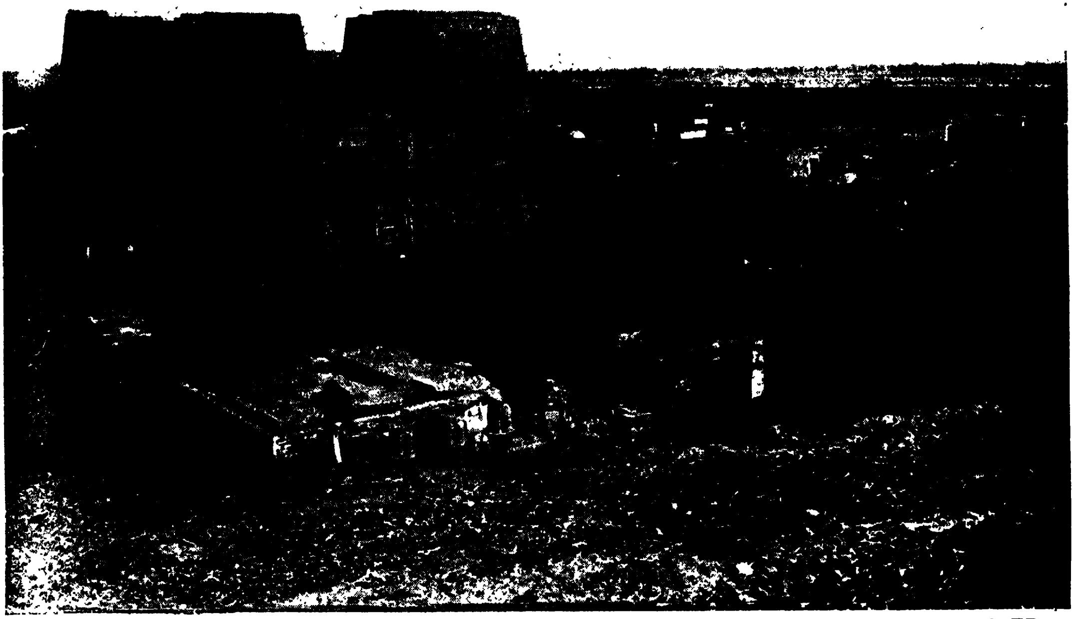


THE LAWS OF HAMMURABI
The sculpture above the laws represents the ruler receiving the code from the sun-god

In the work of digging up Egypt, the French excavators were for many years supreme. Like De Morgan, who has kept out all rivals from Susa and other parts of Persia by obtaining from the Shah the exclusive right to excavate the country, Mariette and other Frenchmen moved the old Egyptian Government to allow them to refuse all other men of science a chance of making any discovery of Egyptian antiquity. Since, however, the British Government became influential in Egyptian affairs, English excavators have been able to go over the ground that the French fancied they had thoroughly explored. Some of the results have been extraordinary. To Professor W. M. Flinders Petrie in particular the world is now indebted for an amazing series of discoveries.

Working privately at the ruins of Tell el-Amarna, he discovered some hundreds of clay tablets of cuneiform correspondence between the kings of Egypt and the kings and governors of Mesopotamia and Assyria. They give only a brief glimpse of an intercourse that lasted some centuries, yet they throw a flood of light on the political and social affairs of the ancient world in the exceedingly critical period of B.C. 1370. We now know more about the royal philosopher, poet, artist, and religious reformer Akhenaton, who then reigned over Egypt, than we do about many of our mediæval rulers. As it is not unlikely that Akhenaton inspired the leaders of Israel with the monotheistic idea, our remarkably full knowledge of his character and career is a very important addition to the history of the development of religion.

All this was only the beginning of Flinders Petrie's work with the spade. For four years a French excavator, Amelineau, had been digging away at a royal burial-place on the edge of the desert near Abydos, in



THE TEMPLE OF EDFU, WHERE MANUSCRIPTS OF SAYINGS OF CHRIST WERE DISCOVERED

THE FAMOUS TERRACE OF SPHINXES WHICH LEADS UP TO THE TEMPLE OF KARNAK

Upper Egypt. The results he at last obtained were of so little value that he threw up the work of excavation a year before the proper time. Flinders Petrie, who had been eagerly waiting for a chance of excavating the most ancient site in Egypt, rushed in with his workmen. Attacking the rubbish-mounds left by his rival, he discovered a line of Egyptian kings more ancient than those known to legend. On a palette of slate was a carving of one of these monarchs, King Narmer, smiting the chief of Fayum, during a campaign in B.C. 4800 that resulted in the whole of Egypt being consolidated into the empire which endured till the thirty-fourth dynasty of the emperors of Rome, and ended in the year A.D. 394.

In the tomb of another king, whose date was 4500 B.C., the English excavator made a still more surprising discovery. He found some yellowish pottery ornamented with red colouring, and of Mediterranean origin. This was much more important than the finding of the correspondence between the kings of Asia and Egypt, thousands of years afterwards. It put back the history of European civilisation to a date as remote as that of the earliest cultures of Susa, Babylonia, and Egypt itself. It had long been the commonplace of literary historians that Europe owed its culture to elements derived from Babylonia and Egypt. The tales of remote native civilisation faintly echoed in works of Homer were dismissed as legends. It was a settled thing that the enterprising merchant sailors of the Phœnician towns of Palestine had carried the germs of civilisation to Crete and the Grecian islands and Greece and Italy. Everything else was a myth—usually a solar myth. But an assistant in a grocer's shop in Germany, who knew scarcely any Greek, had read Homer in a translation, and he came to the conclusion that the story of Troy was an historic fact, which could be proved by excavation in the manner in which Layard had brought about the resurrection of Babylonia.

The grocer's assistant—his name was Heinrich Schliemann—resolved to study Greek, and make a fortune, and use his wealth in digging up Troy town.

THE ARTS OF WAR AND PEACE AS REPRESENTED BY A CHARIOT AND CORN CULTIVATION. AN EGYPTIAN WALL-PAINTING OF FOUR THOUSAND YEARS AGO

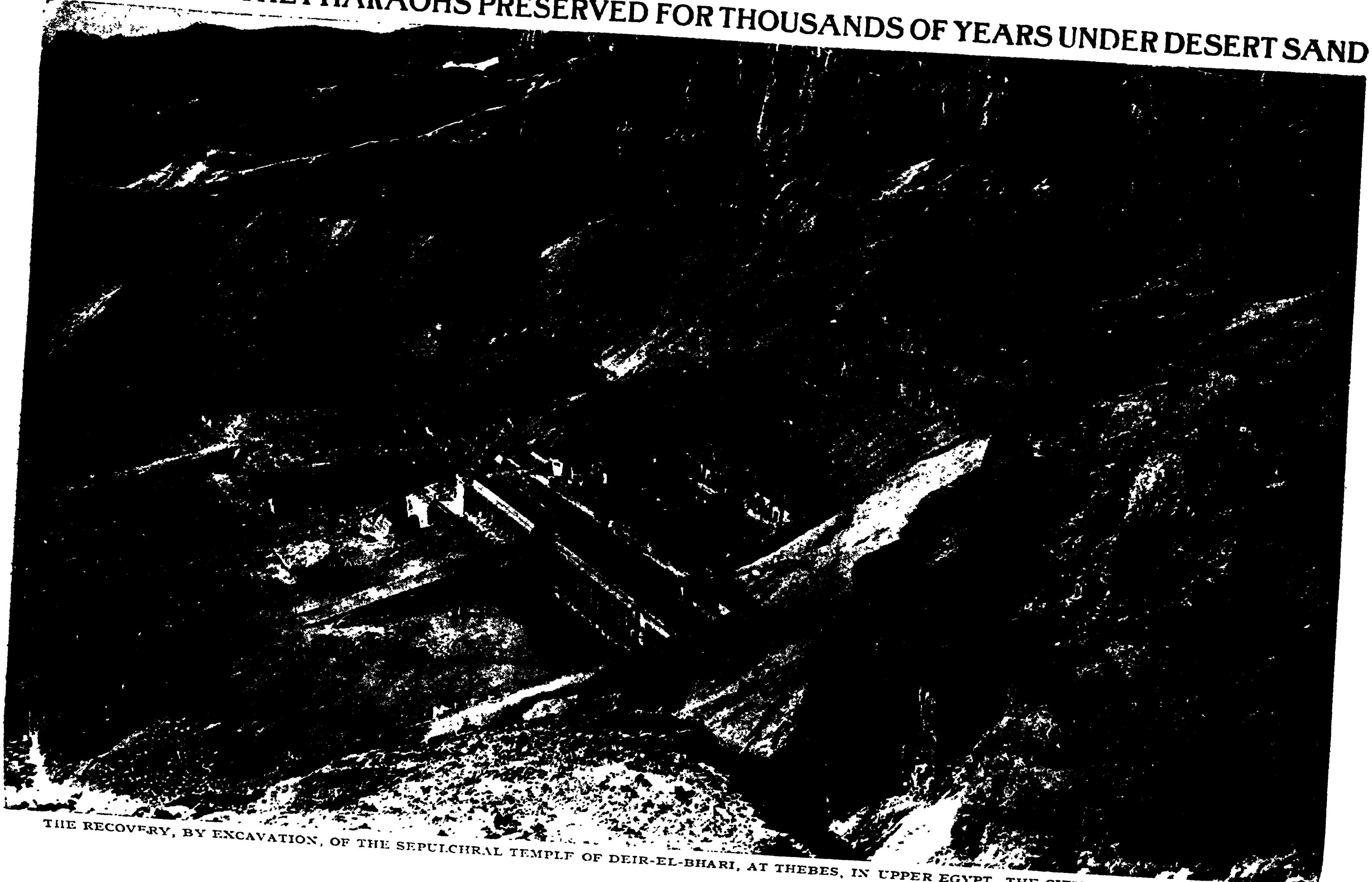
He set sail as a cabin-boy for South America; he was wrecked off Holland; he became the office-boy to an Amsterdam merchant, and while running errands learnt English and French, Dutch, Spanish, Italian, and Portuguese. It took him six weeks to obtain a fair mastery of a foreign tongue. He also learnt Russian, and went to St. Petersburg in 1846 as the agent of a Dutch firm. The next year he set up for himself in business in Russia. By 1858 he had made the fortune that he wanted; but just as he was setting out for Greece a long lawsuit detained him in St. Petersburg for several years. His first preliminary cutting at Hissarlik, where Troy was supposed not to have stood, was made in April, 1870. Then

HE UNEARTHED DESOLATION OF SAMARIA

THE ROMAN BASILICA OF SAMARIA, AND TO THE RIGHT THE CIRCULAR ROMAN TRIBUNE

SUCCESSIVE SUPERIMPOSED REMAINS OF ANCIENT SAMARIA, AS VIEWED FROM THE ROMAN STEPS

A TEMPLE OF THE PHARAOHS PRESERVED FOR THOUSANDS OF YEARS UNDER DESERT SAND



THE RECOVERY, BY EXCAVATION, OF THE SEPULCHRAL TEMPLE OF DEIR-EL-BHARI, AT THEBES, IN UPPER EGYPT, THE CITY OF A HUNDRED GATES

difficulties arose with the Turkish Government, and it was not until March, 1872, that the work was carried on in earnest. Not only did Schliemann find the great excavations from the coast of Asia Minor to the mainland of Greece, and unearthed town after town that had been buried under the dust and drift of thousands of years.

EXCAVATORS AT WORK CLEARING THE SOIL FROM AHAB'S PALACE, AT SAMARIA

fortified town where literary historians said it was not, but close to a great gate that he uncovered, in the heart of the hill he unearthed, the famous treasure of Troy. It consisted of countless ornaments of gold, and many silver and copper vessels and odd weapons. Yet, though he published a detailed report of his discoveries, with ample illustrations and maps, the classical scholars of Europe only laughed at him, and it was not until Gladstone warmly supported him in a preface to his second book of new discoveries that the learned world began to be afraid that they would have completely to revise their ideas of the origin of European civilisation. Schliemann extended his

KING NARMER SMITING THE CHIEF OF FAYUM

From a slate palette of B.C. 4800, discovered by Mr. Flinders Petrie

His success was beyond the wildest dream of his youth. For as he dug deeper and deeper into the ground, and passed beyond the period of Greek and Trojan warfare, he discovered a more ancient civilisation going back some further thousands of years.

After long and anxious study, he came to the conclusion that the origin of the early Mediterranean culture must be sought in Crete. But he died in 1890, soon after making a preliminary excavation of the famous Cretan fortress hill of Knossos. Happily, Sir Arthur J. Evans has been able to undertake the great work which the discoverer of Troy was prevented by death from accomplishing. Again the

results have exceeded expectation. The still existing dark-haired and rather small-statured Mediterranean race, whose descendants live on in Sicily and Sardinia, and constitute a considerable proportion of the population of the British Isles and the more southern countries of Europe, were the originators of one of the earliest civilisations on the earth. It is quite possible that their culture is older than that of Egypt, and at least equal in antiquity to that of Susa and Chaldea.

Thousands of years before the Phœnician traders arrived at Palestine, the Cretans were the masters of the Mediterranean. The remains of their palaces have been found at a depth of nearly six yards below the dust and ruin of the ages. When the excavations were carried down for another seven yards and more, their instruments of the Stone Age were discovered. At a depth of about five and a half yards, Sir Arthur Evans found vases of the foreign type which Professor Flinders Petrie had discovered in a tomb of an Egyptian king of the legendary ages. Then a whole series of stone vases of foreign manufacture has been found in Crete, together with vessels exactly resembling those made in Egypt under the earliest kings. Such are the grounds on which Sir Arthur Evans bases his opinion that the strata at Knossos, in Crete, at a depth of five and a half yards, correspond in point of time with the very first Egyptian dynasties.

A STORE JAR FOUND IN KNOSSOS PALACE, CRETE

From twelve to fourteen thousand years is the possible date of the first settlement of the Cretans. They originally used weapons of stone, and then gradually developed, in the Age of Bronze, a magnificent civilisation, with our modern system of drainage, our modern fashions in feminine attire, and a mysterious literature in a curious script which was probably the origin of our modern way of writing. Their palaces, now dug out of the earth, are magnificent. For some years Sir Arthur Evans has been endeavouring to find the key to the Cretan documents, of which many have now been discovered. We shall have to wait until some means is found of reading the script. When this has been done, the strange and romantic story of Mediterranean civilisation will be fully revealed, and perhaps new paths of exploration will eventually be opened out to the excavators.

In the meantime, we have become well acquainted with the race that invaded Crete and burnt down the palaces there about three thousand two hundred years ago. This race also tried to capture Egypt, but were swept by Rameses III. into Southern Palestine. They became the masters of Greece, and conquered a good deal of Italy, besides overturning Troy. One of their burial-places has been dug up at Hallstatt, in Upper Austria; and here, too, their strange, adventurous history has been revealed. They were our own ancestors. For their stock spread to Ireland, Norway, Russia; and in historic times it occupied most of Europe north of the Alps. They acquired many names. Ancient writers termed them Kelts. All the tall, fair-haired Northern peoples, with blue or grey eyes, are their descendants. They are now generally known as Teutons; but the tall Highlanders of Scotland and the tall Irishmen and Welshmen come from them. Indeed, the ancient Irish and the Homeric Greeks represent them best. So let us call them the Nordic race. The branch that settled at Hallstatt used bronze tools and

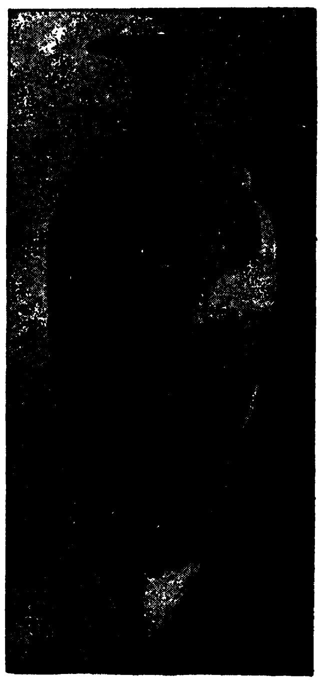
THE THRONE ROOM AND THE THRONE IN THE EXCAVATED PALACE AT KNOSSOS, CRETE

These photographs, and those on pages 3990 and 3992, are by courtesy of Sir A. J. Evans, F.R.S.

weapons, but they found in their new home a kind of iron that did not need tempering; it was already smelted by Nature. This they began to use in ornaments; then they made the cutting instruments of their industries from it, and so very slowly replaced their bronze tools and weapons with iron. Finally, they gave their iron instruments new forms suited to the material, and quite unlike all bronze castings.

THE EXCAVATED PALACE OF PHÆSTOS CRETE

In every other place in the world that has been deeply excavated, the change from bronze to iron is sudden. Only at Hallstatt is there a gradual and connected development between the age of bronze and the age of iron. This means that the Nordics of Hallstatt were the originators of the Iron Age. And now that their swords, javelins, spears, arrow-heads, and shields of the new metal have been dug up, the history of the Iron races is at last known. Having made great advances in weapons and armour, they hewed their way through the civilisations of the Mediterranean, and became the new masters of the inland sea. In Greece and Asia Minor they were the Greeks of Homer. In Crete they were the founders of the naval supremacy of Minos. In the Holy Land they were the Philistines whom the Israelites encountered when they invaded the country from the desert side. In Italy they were the Umbrians. At the present time there is a good deal of dispute as to the original home of these Northern Europeans. Some writers are inclined to think that they were Berbers from Northern Africa, who were changed by their long sojourn in the colder climate of the region above the Alps. But a good many excavators are gradually tending to the conclusion that they came from the grass-lands between the Caspian Sea and the deserts of Turkistan. As yet there is little beyond the evidence of some broken pottery of special design found at the New Stone Age level at Susa in Persia, Anau in Turkistan, and at places in Asia Minor, and amid the grassland of Thessaly, in Greece. It is found, also, at a number of points on the north side of the Black Sea, and thence into the Balkan Peninsular as far south as Macedonia.



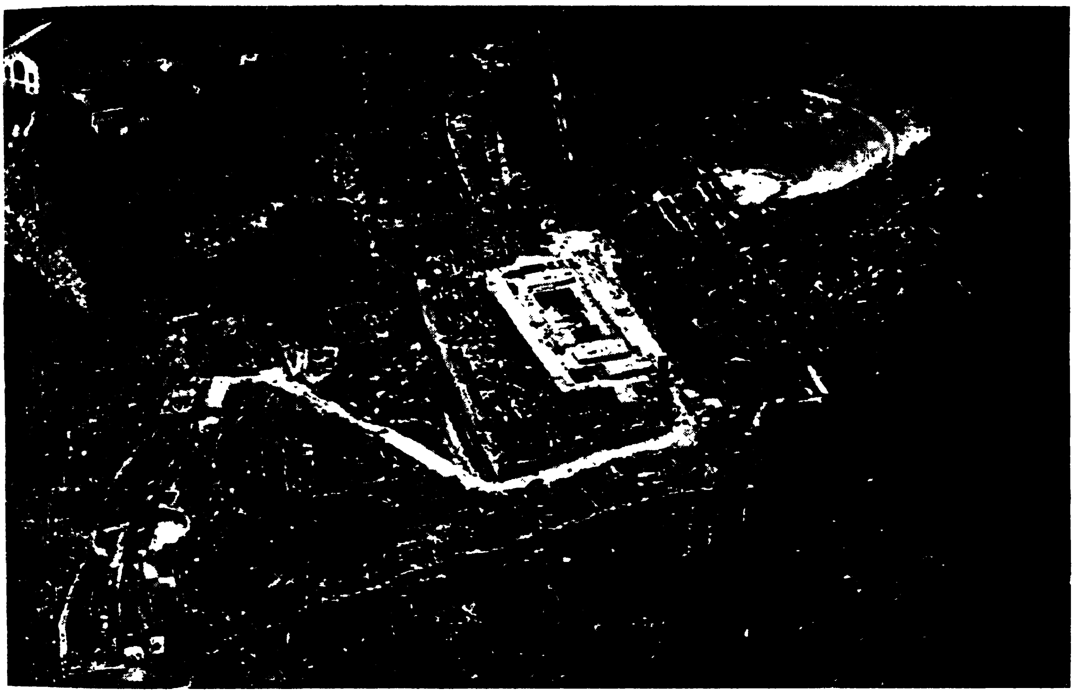
A VASE FOUND AT ZAKRO IN CRETE

The excavations in Turkistan also show that the race using the pottery had domesticated the cow and the horse at a very remote time. They were a wandering pastoral people; and when they were compelled to migrate by reason of a terrible drought—signs of which are also seen in the excavations—they kept to the grasslands leading from Central Asia to Europe, invading and breaking down on their way all the most ancient civilisations of the world.

Thousands of years passed before they learnt to use the new metal they found at Hallstatt, and to prove that iron is master

of gold. Such is the remarkable story of our ancestors revealed in very faint outline from the chance discovery of some broken pottery in a few widely scattered excavation pits. An extraordinary amount of digging will have to be done before the story is fully confirmed and made much clearer. One of the most famous of our excavators, Dr. M. A. Stein, has been longing for years to go to Turkistan and carry out a large, scientific plan of trenching there. But he is an official in our Indian Educational Department, and for some unknown reason his superiors are strangely averse from supporting him. Yet he has already proved that he has quite remarkable genius as an excavator. Working amid the blinding, deadly sandstorms of the westernmost part of the immense desert of Central Asia, he has dug up there a vanished Indo-European civilisation, and added greatly to the treasures of the British Museum. Great cities, now buried in the sand, have been unearthed by him, and made to reveal their history as the meeting-place between the thought and art of Europe and India and China. He has recovered thousands of documents, pictures, sculptures, and the clothes and food and furniture of the races that were at last driven by a dreadful drought from the desert they irrigated. It is much to be hoped that Dr. Stein will obtain the funds and the time he needs for pursuing his excavations around the Oxus.

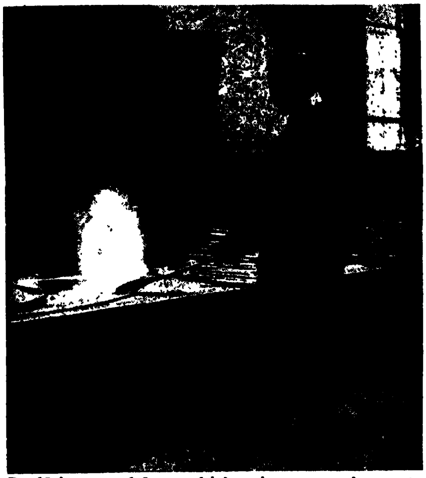
Since the recent discovery of an aboriginal tribe of Red Indians in Siberia, it has become pretty certain that Eastern Asia was the early home of the Red Indian nations of America. So we cannot expect any excavations in Peru or Mexico to equal in historic interest the spade-work done in the Old World. But the native empires of the Incas and the Maya are worthy of the attention of the American excavator. For it is now fairly well known that there is evidence of a more ancient culture than those of the mediæval Peruvians and Mexicans.



THE RUINS OF THE SACRED CITY OF DELPHI, AS VIEWED FROM MOUNT PARNASSUS

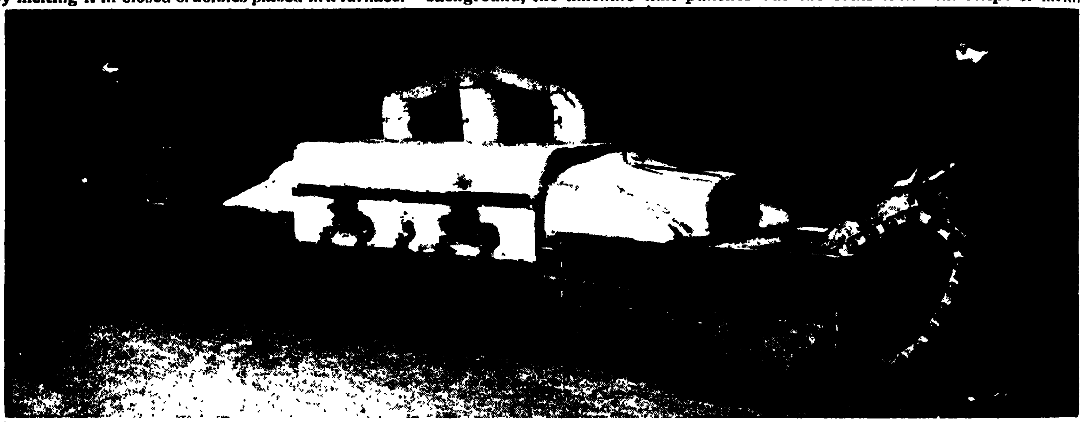
China also awaits the scientific digger. At present its most ancient art seems to indicate a remote connection with the art of the races of the South Pacific Islands. The deserts of Northern Africa are also awaiting the explorer with a spade. The origins of the earliest known culture of Egypt may be found in Tripoli. And there is the mysterious Berber—tall, fair, and blue-eyed—who may have concealed in his native soil that evidence of the origin of the Northern European race which one school of pre-historians still expects to find there.

THE REAL MONEY-MAKERS OF THE MINT



Purifying metal from which coins are to be made by melting it in closed crucibles placed in a furnace.

The machine that raises the edges of coins, to lengthen their wear, and, in the background, the machine that punches out the coins from flat strips of metal



The fierce furnace through which all coins pass, slowly carried in little iron boxes on an endless chain, preparatory to being stamped.

Passing in by the tube on the left, the coins are stamped between the two dies in the foreground.

A wonderful automatic machine at the Mint that tests finally all coins, counts them, weighs them, and drops them into bags, ready to be taken to the banks

DEAR AND CHEAP MONEY

The Great Responsibility Resting on the Bank of England Through its Gold Reserve

THE BANK AS A SYNONYM FOR SAFETY

The Bank of England, today the most respected and most solid of all the financial institutions of the world, had a curious origin. At the end of the seventeenth century, when, as had often been the case before, we were engaged in a war with France, and when James II. had but recently flown across the seas, the throne of William and Mary rested upon the support of the Whigs. As we need hardly remind the reader, the political parties of that time have no relation whatever to the parties of today which sometimes bear the same names. The Tories cherished still, as indeed for long afterwards, the idea of a Stuart restoration. The prosecution of war with France, the backer of the Jacobites, called for money, and where was money to be had? It was in these circumstances that a company of Whig merchants of the City of London conceived the idea of forming a limited liability company to lend money to the Government. At that time, of course, trading with limited liability was a rare thing, and the Royal Charter of 1694, which was issued by William III., establishing the "Governor and Company of the Bank of England," conferred an exceedingly valuable privilege.

The company or society thus named raised the sum of £1,200,000 by tempting the public with interest at 8 per cent., and so it came about that William III. got his money for the war with France, the English National Debt began, and the "Old Lady of Threadneedle Street" was born. The whole of the money raised went to the Government, and the company was given power to issue banknotes for the amount of £1,200,000, Government security being thus behind the notes. It is remarkable, but nevertheless a fact, that in these early years, when the return of James was still a possibility, the security of the Bank of England rested solely upon the predominance of the Whigs. If the Stuarts had come back, they would undoubtedly have repudiated the Charter granted by William III., and the 8 per cent. would no longer have been forthcoming. The money was, nevertheless, cheerfully subscribed by the Whigs, and that fact was a sign of their faith in the stability of the House of Orange.

Not very long after its incorporation the Bank was given a monopoly of joint-stock banking by a law which forbade other banking firms to have more than six partners. This monopoly was not cancelled until more than a century later, and during the long interval banking was necessarily confined to the operations of private firms. In 1826 this law was repealed, but even then the Bank of England was given the exclusive privilege of issuing banknotes within a radius of sixty-five miles of London.

The original loan of £1,200,000 was soon increased, as we may easily imagine. The Bank of England lent £11,015,100 to the State, and up to this sum it possessed the right to issue banknotes upon Government security. Beyond this it could issue notes upon its own private security. The original Government debt of £11,015,100 remains to this day, and still figures in the weekly banking return of the Bank of England, as will be seen by reference to the Issue Department return for November 6, 1912, which we print in these pages.

We have already seen that in 1844 the Bank Charter Act was passed to revise the conditions of note issue, to substitute Bank of England notes for the note issues of other banks, as far as possible, and at the same time to make the Bank of England note absolutely safe by ensuring that it should be backed either by Government security or actual gold. Let us now turn to the complete weekly return of the

Bank of England, made in accordance with the Act, part of which we referred to in the last chapter. Here is the complete account.

BANK RETURN

An account pursuant to the Act 7 & 8 Victoria, cap. 32, for the week ended on Wednesday, the 6th day of November, 1912.

ISSUE DEPARTMENT

	£		£
Notes Issued	53,615,625	Government Debt	11,015,100
		Other Securities	7,434,900
		Gold Coin and Bullion	35,165,625
	£53,615,625		£53,615,625

BANKING DEPARTMENT

	£		£
Proprietors' Capital	14,553,000	Government Securities	13,037,909
Rest	3,209,921	Other Securities	33,908,003
*Public Deposits	10,204,260	Notes	24,978,575
Other Deposits	45,300,254	Gold and Silver Coin	1,384,255
Seven Day and Other Bills	41,307		
	£73,308,742		£73,308,742

* Including Exchequer, Savings Banks, Commissioners of National Debt, and Dividend Accounts.

With this before us, we are able to understand the all-important work of the Bank of England. The Bank, in accordance with the Act of 1844, has two *distinct* departments—the "Issue" Department, which is solely concerned with the issue of notes, and the "Banking" Department, which is solely concerned with the ordinary business of banking. We see how the original debt of £11,015,100 stands to the credit of the Bank, and that against this and other securities the Bank issues notes, the balance being secured in gold. Any person may go to the Bank of England and demand Bank of England notes in exchange for gold at the rate of £3 17s. 9d. per ounce. The Bank of England note, however, for all its safety and profound respectability, is no longer an important factor in currency and trade, and the number in use among the public steadily falls. The use of the cheque has reduced the number, but the banknote still fulfils a use as standing for so much gold or Government security, and as the equivalent of gold it is used by bankers as part of their working, hour to hour, ready cash or "till money."

A Bank of England note simply consists of a promise to pay a certain sum on demand, and what it really means is a receipt for gold lodged with the Bank, and therefore as good as gold.

It will be perceived that it is not a matter of profit to the Bank to issue banknotes for gold; on the contrary, it is trouble for nothing, for the note is a receipt for gold deposited, which gold must be ***produced on demand*** in return for the notes. As far as the issue of banknotes against the Government debt and securities is concerned, there is obviously a matter of profit, but there is no profit to be made by the Bank in changing gold for notes or notes for gold.

It is, of course, a great convenience to the holder of gold to be able to take his precious metal to the Bank for safe custody, and to receive notes in exchange, and, in practice nearly all gold does go to the Bank in this way. The holder of gold, however, can take it to the Mint, and have it coined into sovereigns at the gold standard rate, which is equivalent to £3 17s. 10½d. per ounce. The precise particulars are that gold eleven-twelfths pure (or eleven-twelfths "fine," as it is said), is coined by making 1869 sovereigns out of 480 ounces of metal. Thus, the "Mint price" of gold is 1½d. higher than the Bank price. In practice people do not take gold to the Mint, for they would have to wait for their sovereigns. Instead, they send it to the Bank of England, and the Mint gets its gold from the Bank of England when new currency is needed.

The Bank Act does not compel the Bank to deal in any particular way with the gold which it holds; it simply enacts that it must issue notes when required in exchange for gold, and that it must cash its notes in gold. The Bank of England becomes the sole depository of gold in the greatest gold market of the world; and when gold is required for shipment in payment for goods, which is sometimes the case, as we shall see presently, it can supply an exporter with either sovereigns or bar gold.

Now let us pass to that part of the above Bank Return which is headed "Banking Department," and which, we repeat, is

quite separate and distinct from the Issue Department. It will be seen that the Bank's capital is enormous, being nearly £15,000,000. The strength of the Bank is not only determined by this, and by its peculiar position as banker of the British Government. The reader will see that under the first line on the debtor side, "Proprietors' Capital," there is a second line, "Rest," £3,209,921. This "Rest" is a reserve fund, so that the capital of the Bank on November 6, 1912, amounted to nearly £18,000,000. The deposits are seen to be £10,204,260 of "Public Deposits," and £45,300,254 of "Other Deposits." The public deposits consist of the revenue of the nation as it is received from day to day by public revenue officials and paid into the Bank, and of the various balances of public funds.

How the Bank of England Holds the Gold Reserves of the Whole Country

The keeping of this all-important account has given the Bank a prestige which no other banking institution can possibly obtain. It will be understood that the public deposits with the Bank vary considerably during the year; sometimes they are as low as a few millions, and sometimes they are more than ten times that amount.

Now for the "Other Deposits." These consist not only of the accounts of private customers, but of the *deposits of other banking institutions.* The Bank of England is a *bankers' bank,* and we have clearly to understand that the greater part of the cash reserves of all the banks of the country are held by the Bank of England. For ordinary working, bankers keep only a small supply of sovereigns and banknotes; the greater part of their cash balances is lodged with the Bank of England, and appears in the return under "Other Deposits." When, therefore, we get these weekly Banking Department returns of the Bank of England, we have a key to the gold reserve of the country, and we see how small it is in relation to the enormous amount of deposits which are made with bankers. Looked at in this way, we see how amazing it is that the hundreds of thousands of current debts payable on demand in gold are backed by such a tiny amount of actual gold cash.

Should the Bank of England Publish the Amount of Reserves of Other Banks?

The reader will now realise how great are the responsibilities of the Bank of England. As has been well said by Bagehot: "On the wisdom of the directors of that one joint-stock company it depends whether England should be solvent or insolvent."

It should be remarked that we do not know, for the Bank of England does not tell us, what part of the "Other Deposits" consists of the deposits of its own private customers, and what part consists of the deposits made with it by other bankers. It would probably be a great public advantage if this information were available, and if, further, there were clearly stated in the Bank of England return details of the deposits of various banks held by its banking department. In this connection we may note the practice of "window-dressing" which is indulged in by the joint-stock banks in order to impress the readers of their balance-sheets. Periodically joint-stock banks swell their deposits at the Bank of England in order to make a show of big reserves in their balance-sheets. This not very creditable practice would cease if the Bank of England were compelled to publish, weekly, precise details of the deposits made with it by all banks. We should then know every week what each bank had on deposit at the "bankers' bank."

We have now to turn to the credit side of the Banking Department account. The first line, "Government Securities," just over £13,000,000, needs little elucidation. It refers, of course, to such securities held by the Bank as possess the British Government's guarantee—Consols, for example.

The All-Important "Reserve" of the Bank of England in Money and Notes

The next line, "Other Securities," nearly £34,000,000, represents the general investments of the Bank, and particulars of them are not furnished. We know that they consist partly of gilt-edged securities, partly of loans advanced on security, and partly, again, of bills of exchange. The unequalled standing of the Bank is our security that this figure of £34,000,000 is a good credit.

We now come to two all-important lines:

	£
Notes	24,978,575
Gold and Silver Coin	1,384,255
Total Reserve	26,362,830

These two lines together constitute what is called the Bank's "Reserve." The reader must carefully guard himself *not to confound this important item with the reserve of gold of the Issue Department.* It will be seen on a moment's reflection that the gold reserve of the Issue Department is not a security in relation to the Bank of England's banking operations, but the gold represented by its banknotes, and so the security for them.

It is necessary to insist again that the Issue and Banking Departments are quite separate, and the Reserve we are now considering, and which is what is meant when the Bank of England's " Reserve " is referred to, is the gold, or equivalent of gold, which the Bank of England *as a bank* holds as security for its banking transactions. It will help us, indeed, if we imagine the Issue and Banking Departments as separate institutions. We see the Issue Department holding gold to back its notes. We see the Banking Department holding a tiny amount of gold (£1,384,255) and a large amount of banknotes (£24,978,575), which is as good as gold because the notes have gold held against them by the Issue Department.

Having made this clear, let us notice that when a large amount of gold is taken from the Issue Department it diminishes the Reserve of the Banking Department. That happens in this way. Suppose the customer of a certain bank desires to ship £1,000,000 in gold. He could not get it from his banker, for his bank keeps very little gold. The bank would draw upon its credit with the Bank of England's Banking Department, and obtain £1,000,000 worth of banknotes. The customer would then take the notes to the Issue Department and demand gold for them. Thus the shipping away of £1,000,000 worth of gold would decrease the Reserve of the Banking Department by £1,000,000, for it would have parted with £1,000,000 of banknotes.

The Smallness of the Reserve Held Against a Possible Demand for Gold

We see how small is the Reserve thus held against demands for gold. With the Reserve at the figure at which it happened to be in this week in November, 1912, the withdrawal of £1,000,000 of gold would have meant the loss of one-twenty-sixth of the whole—a very considerable proportion. Little as the £26,000,000 may seem, upon it rests the entire fabric of credit. In the last chapter we described this matter in general terms ; here we have before us the actual fact. The hundreds of millions of pounds' worth of deposits made with all our banks are payable in gold on demand. All the banks put together have nearly all the gold they possess at the Bank of England. The Bank of England, we see, has a mere £26,000,000 worth of gold to call upon. The Post Office Savings Bank alone has £160,000,000 of deposits, so that there is not enough gold in the Bank of England Reserve to pay one pound in six of these deposits, to say nothing of deposits with private banks.

The Bank of England is a public and yet a private institution. We see that it fulfils the most important functions, but it remains today, as it has always been, an institution fulfilling responsibilities without acknowledging any particular duty in the matter. It must be conceded that the Reserve has been increased, but most certainly it has not been increased in proportion to the trade and finance of the country. In the 'seventies and 'eighties the Reserve ranged from £12,000,000 to £15,000,000; in the 'nineties it rose to over £20,000,000; it is now, as we have seen, about £26,000,000. That is to say, our gold reserve, although actually greater, is relatively smaller than it used to be.

"All Banks Depend upon One, and All Merchants Depend on the Bankers"

As to the Bank of England's view of its responsibilities, Bagehot, writing in 1873 in his famous " Lombard Street," remarked : " All banks depend on the Bank of England, and all merchants depend on some banker. If a merchant have £10,000 at his banker's, and wants to pay it to someone in Germany, he will not be able to pay it unless his banker can pay him, and the banker will not be able to pay him if the Bank of England should be in difficulties and cannot produce his reserve. The directors of the Bank are therefore, in fact, if not in name, trustees for the public, to keep a banking reserve on their behalf ; and it would naturally be expected either that they distinctly recognised this duty and engaged to perform it, or that their own self-interest was so strong in the matter that no engagement was needed. But, so far from there being a distinct undertaking on the part of the Bank directors to perform this duty, many of them would scarcely acknowledge it, and some altogether denied it."

How the Bank's Reserve is Affected, and How it Matters to All Business

These words are as true today, in 1912, as when they were written. The Bank of England does not admit responsibility, and yet it is responsible. Successive Governments acknowledge that the subject is important, and pass on to less important matters. In view of the great importance of the subject, we must now see what it is that chiefly affects the Bank's Reserve of gold, and what the Reserve matters to the man in the street. Unfortunately, these things matter very much in the ordinary affairs of life ; and while there are few newspaper readers who understand the money column, there may be large groups of men

unemployed, and traders bitterly suffering, because of things happening which are recorded in the money column—recorded plainly for those who understand, and obscurely for those who do not.

It becomes necessary to show the part which gold plays in international trade and the foreign exchanges. Foreign transactions have much to do with the Price of Money. What do we mean by the price of money? How can money have a price? The answer to these questions is that the word "price" here means something quite different from price as applied to goods. The price of a commodity means the amount of money for which it will exchange. The price of money means the rate of interest asked for the loan of it.

The Way in which Ordinary Trade is Affected by the Bank Rate

When we speak of the "Money Market" we mean the places in which money may be borrowed. Very clearly, when money—*i.e.*, loan money—is in plentiful supply, the rate of interest is low, and money is said to be "cheap." When money is scarce, and loans are difficult to negotiate, the rate of interest is high, and money is said to be "dear."

Of course, it matters a great deal to the business man what the price of money is. If a builder, for example, has to pay 5 per cent. for money instead of 4 per cent., it makes a very great difference indeed to his chance of a successful speculation. If the price of money rises, we have an immediate check to trade; and, conversely, when money is plentiful, trade is stimulated. Of course, there is action and reaction. Good trade, by creating a demand for loans, tends to raise the price of money, and vice versâ.

We showed in the last chapter how goods are exchanged for goods in the same country by means of promises to pay gold, which we call cheques—promises which are set off against each other by bankers. This setting-off renders the passing of gold in business almost entirely unnecessary, and, of course, explains why the tiny reserve of gold at the Bank of England works so smoothly.

When Gold Becomes Necessary to Balance International Payments

When we come to our external commerce, the promises to pay gold take the form of bills of exchange, which are actually promises to pay gold at some future date. We do not pause here to explain the machinery of the bill of exchange in detail, for the reader will not be misled if he imagines the process to result in the same way as the exchange of cheques, described in the last chapter. It will be apparent, however, that if two countries, say France and England, have trade with each other, it is highly improbable that at any given time the goods sold by Frenchmen to Englishmen will be equal in value to those sold by Englishmen to Frenchmen. Therefore, it may not be at any given moment impossible to set off paper promises to pay in such manner as entirely to resolve the transactions between the two nations. Of course, in practice the setting-off takes place between more than two nations, but it simplifies what we have to explain to fix our minds upon two nations only.

Imagine, then, that at a given time the goods sold by France to England, and due to be paid for, are worth £5,000,000, while the goods sold by England to France, and due to be paid for, are worth £4,900,000. It will be seen that, so far as £4,900,000 is concerned, all that need be done is to set off promises to pay gold against each other, leaving a balance of £100,000. Under these circumstances, the £100,000 must be paid in actual gold shipped from England to France. It would thus become necessary to obtain gold from the Bank of England and to export it to France. As a consequence, the reserve of gold at the Bank of England falls, and the money market is affected.

Why the Price of Money is Raised in London from Time to Time

How, then, does the Bank of England protect its gold reserve from such depletion? It has both to supply gold on demand and yet to prevent its Reserve from falling to a dangerously low point. To give the answer in the simplest form, what the Bank of England does is to *raise the price of money in London*. The means by which it effects this is by raising what is called the Bank-rate, and the Bank-rate is the rate at which the Bank of England will discount first-class bills of exchange or lend money on good security for short periods. The official Bank-rate, because of the peculiar importance and power of the Bank of England which prescribes it, determines the market rate, or practical rate of discount, which runs a shade below it. It will be apparent that when money thus becomes dearer in London, through the raising of the Bank-rate, gold begins to flow to London to seek profitable employment, and thus the Bank attracts gold. Experience has shown again and again that the raising of the Bank-rate is effective in bringing gold to London.

The Bank has not infrequently thus to protect its gold reserve.

Thus, when in 1907 there was financial panic in America, when American citizens were rushing to their banks for gold, and America began to call on London for gold, the Bank raised its rate, and prevented too great a drain upon its resources. The machinery may seem delicate to those who are made acquainted with it for the first time, but, fortunately, in practice it is remarkably efficient. When London, through the Bank of England's raising of the Bank-rate, offers high interest for the use of gold, a stream of gold begins to flow towards the greatest gold market of the world.

The Difficulty that Arises from the Varying Values of National Coinages

As the late Lord Goschen put it in his famous work on the Foreign Exchanges, "A high rate of interest attracts capital from abroad, and the effect of this attraction is immediately perceptible in the Exchanges. An export of gold would be the result either of a settlement of indebtedness or of differences in the value of money or of deficiencies in currency."

So far we have avoided the difficulty that different countries have different coinage, but we must now consider this in detail, and see how foreign exchanges are in practice regulated.

It will be readily understood that as between the gold coins of two gold-standard countries the question is not what the coins are called, but what is the amount of pure gold in the coins. Considering this, what is called the Mint Par of Exchange is arrived at. For example, what is the relation of the pure gold in the French coinage (napoleons) to the pure gold of the English coinage? This is easily calculated, and we find that an English sovereign has as much pure gold in it as rather more than twenty-five francs—the precise equivalent is 25·22 francs. In the same way, the Mint Par between England and Germany is that £1 equals 20·43 marks.

The Causes of the Rise and Fall of the Rates of Exchange

Again, the Mint Par between the United States and England is 4·867 dollars to the £1. We hope we have made it clear that the Mint Par of exchange has sole relation to the amount of pure gold contained in the various coins. Obviously, as between a gold-standard country, such as England or France, and a silver country, like China, there cannot be a Mint Par of exchange. Now let us suppose that as between two countries the claims for payment at a certain time are equal. That being so, exchange is at the theoretic par of exchange—*i.e.*, if the two countries were France and England the claims would be settled at the exchange rate of 25·22 francs to the English sovereign. But, of course, it rarely happens that there is such an equivalence of indebtedness between any two countries; and it will be seen that if on a certain date there is more to remit from France to England than from England to France, there will be a considerable demand in France for bills of exchange as a means of remittance to London. Consequently, the price of a bill of exchange would rise in Paris, or, in other words, the rate of exchange would rise.

To express it in another way, a bill on London would be at a premium; a French merchant desiring to remit would be willing to pay more than the Mint Par of exchange—*i.e., more than 25·22 francs per sovereign for it.* There is, however, a practical limit to the premium he would be willing to pay. That limit is fixed by the cost of buying, shipping, and insuring gold, and that limit is known as Specie Point. A moment's thought will show that this Specie Point strictly limits the premium of exchange, and is the point at which gold is paid instead of a bill of exchange, or promise to pay gold.

The Insignificance of the Commerce in Gold Compared with the Bulk of Trade

Now we see how it is that gold comes to be shipped in settlement of debts between one country and another. In relation to the enormous bulk of international transactions which take place, the shipments of gold are trifling. In point of actual size, however, the shipments of gold are great. For example, in the year 1911 the commerce in goods, gold, and silver of the United Kingdom was as follows.

SHIPMENT OF GOODS AND THE PRECIOUS METALS, 1911

	£
Imports of Goods	680,000,000
Exports of Goods	454,300,000
Exports of Imported Goods	102,700,000
Total Trade in Goods	1,237,600,000
Bullion and Specie Imported	£63,000,000
Bullion and Specie Exported	£57,000,000

It will be seen that while in a single year our imports and exports of merchandise amounted in value to the enormous sum of £1,237,000,000, our inward and outward shipments of bullion and specie

amounted to only £120,000,000. It is plain, therefore, that the great bulk of the necessary payments were made by the transmission of bills of exchange, and that the shipment of gold played only a small part comparatively. Nevertheless, when our transactions in gold are compared with the gold reserve at the Bank of England, we get a very different effect of proportion. In relation to our trade the commerce in gold is insignificant; *in relation to the Bank Reserve* the *commerce in gold is considerable and significant.* We see that it is large enough and frequent enough to have a very appreciable effect on the money market.

We can understand, then, how important are the tables headed "Foreign Exchanges" which appear in the money columns of the daily newspapers, and how closely they are watched. The movement upward or downward of rates of exchange with any particular country shows in which direction the balance of indebtedness is tending. For example, here are the rates of exchange as they were given in the daily newspapers of November 22, 1912.

there were a number of fluctuations. Expressing the meaning of the table broadly, it is this. It shows at the dates named the price which had to be paid for a bill of the period mentioned on the place named. In considering the exchange table we have to bear in mind what "higher" or "lower" means. If, for example, the German exchange rises, it means that the English sovereign exchanges for a greater number of marks. Therefore, the higher the rate of exchange in the table for a certain country, the more we get for our sovereign in buying a bill of exchange.

We can now understand how it is that the price of money, or the interest to be paid for the loan of it, so constantly varies. Apart from the effects of supply and demand due to the condition of trade, we have the ever-present effect of the foreign exchanges. As a result, the charge for discounting an approved bill of exchange may vary considerably from month to month or even from week to week. The question arises whether, if the Bank of England were to maintain a much greater gold reserve, it would not be possible to

FOREIGN EXCHANGES EXPLAINED

Towns and Countries		Tues., Nov. 19		Thurs., Nov. 21		Meaning
Amsterdam, etc.	cheques	12 1$\frac{7}{8}$	12 2$\frac{1}{8}$	12 1$\frac{7}{8}$	12 2$\frac{1}{8}$	Florins and stivers for £1
Amsterdam, etc.	3 months	12 4$\frac{7}{8}$	12 5$\frac{3}{8}$	12 4$\frac{7}{8}$	12 5$\frac{3}{8}$	,, ,,
Antwerp and Brussels ...	,,	25 65	25 70	25 66$\frac{1}{4}$	25 71$\frac{1}{4}$	Francs and centimes for £1
Hamburg	,,	20 80	20 84	20 79	20 83	Marks and pf. for £1
Berlin, etc.	,,	20 80	20 84	20 79	20 83	,, ,,
Paris	cheques	25 22$\frac{1}{2}$	25 25	25 22$\frac{1}{2}$	25 25	Francs and centimes for £1
Paris	3 months	25 48$\frac{3}{4}$	25 53$\frac{3}{4}$	25 48$\frac{3}{4}$	25 53$\frac{3}{4}$	,, ,,
Marseilles	,,	25 48$\frac{3}{4}$	25 53$\frac{3}{4}$	25 48$\frac{3}{4}$	25 53$\frac{3}{4}$	,, ,,
Switzerland	,,	25 65	25 70	25 65	25 70	,, ,,
Austria	,,	24 58	24 62	24 58	24 62	Florins and kreutzers for £1
St. Petersburg, Moscow ...	,,	24$\frac{3}{4}$	24$\frac{7}{8}$	24$\frac{3}{4}$	24$\frac{7}{8}$	Pence for 1 rouble
Genoa	,,	25 87$\frac{1}{2}$	25 92$\frac{1}{2}$	25 87$\frac{1}{2}$	25 92$\frac{1}{2}$	Lire and cents. for £1
New York	60 days	48$\frac{5}{8}$	48$\frac{3}{4}$	48$\frac{3}{8}$	48$\frac{3}{4}$	Pence for 1 dollar
Madrid	3 months	44	44$\frac{1}{4}$	43$\frac{3}{8}$	43$\frac{7}{8}$	Pence for 1 peso
Lisbon	,,	45$\frac{3}{8}$	45$\frac{7}{8}$	45$\frac{1}{8}$	46	Pence for 1 milreis
Oporto	,,	45$\frac{3}{8}$	45$\frac{7}{8}$	45$\frac{3}{4}$	46	,, ,,
Copenhagen	,,	18 51	18 55	18 52	18 56	Kroner and ore for £1
Christiania	,,	18 52	18 56	18 53	18 57	,, ,,
Stockholm	,,	18 52	18 56	18 53	18 57	,, ,,

It will be noticed that two prices are given for each of the days. The first of these prices is for first-class paper; the second for ordinary or second-class paper—this will be readily understood. It will be seen that on November 19 the Paris Exchange was very slightly above Mint Par for a cheque, and considerably above it for a three months' bill—interest, of course, accounting for this. A glance over the table will show that as between Tuesday and Thursday in the same week

make the bank-rate more constant. Sir Inglis Palgrave seems to show in his "Bank Rate and the Money Market" that "the variations of the rate of discount at the Bank of England have been far more severe" in the last fifty years than at the Banks of France, Germany, Holland, or Belgium. Moreover, he points out that the fluctuations in our Bank-rate are disproportionate to the fluctuations in any other of our business movements. As every man of business must at some time

or other use borrowed money, the high rate of fluctuation referred to is a very serious matter indeed.

We have to realise that it is not the wealth of the country, or the prosperity of the country, or the amount of capital in the country which governs the price which has to be paid for money at any given time. The immediate influence is the Reserve of the Bank of England—that Reserve which we have seen to consist of so small a sum, comparatively speaking, as about £26,000,000. If the foreign exchanges are unfavourable—*i.e.*, if gold is drawn abroad—we find our Reserve so small that a small actual drain comes to have a considerable effect because of its considerable ratio to our inadequate Reserve. If our Reserve is £20,000,000, and £1,000,000 is exported, our gold is reduced by 5 per cent.; if our Reserve is £40,000,000, and £1,000,000 is exported, we have parted with only 2½ per cent. It is perfectly true that the larger we make our national gold reserve, the more capital we have lying idle. The gold which lies in the vaults of the Bank of England is, it must be admitted, just so much unemployed capital.

Against this consideration, admittedly an important one, we have to put the fact that we cannot afford that our money market should lack stability; and if a greater degree of stability is to be secured, as would certainly appear to be the case, by appreciably increasing the Reserve, it is a national duty to do it. For every £10,000,000 of increase, calculating interest at 3 per cent., we sacrifice £300,000 annually. £600,000 a year might perhaps be not too much to sacrifice in order nearly to double the gold reserve, for it may easily be that the present avoidable and unnecessary disturbance of the money market causes a loss to British trade of many times that sum on the average, taking good and bad years together.

Before the writer there lies the Bank Return of July 2, 1879. It shows a Reserve of nearly £21,000,000. As we have seen, at the present time the Reserve is about £26,000,000, an increase of only £5,000,000 in thirty-three years. Let us compare the trade, the banking, and the gold reserve of 1880 and 1911.

It is true that the Reserve in 1879 was above the average of the time, but, when allowance is made for that, the facts of this table remain exceedingly remarkable. The figures show that in the thirty-three years imports have nearly doubled, exports of British goods have more than doubled, and exports of imported goods have nearly doubled. The figures also show that the cheques and bills cleared by the Bankers' Clearing House have actually trebled in value. It is obvious that the magnitude of our trading and financial transactions has grown enormously, and yet the edifice of credit in 1911 has a base not much larger than the much smaller edifice of 1880. It is true that the financial machine works on the whole with considerable smoothness, and that much less trouble is experienced than might well be expected. The substantial basis of credit is essentially something much wider than the gold at the Bank of England. But the fact remains that the price of money is very nearly connected with, and related to, not the mass of our trade or capital, but the vagaries which are occasioned by forces that touch the small Reserve of our central banking institution.

Perhaps the best way out of the difficulty would be for the Government both to compel and to aid the formation of a greater Reserve. It might apply compulsion by enacting that every banking institution should maintain a definite Reserve, proportionate to its deposits, at the Bank of England. We know very well that the joint-stock banks, with their magnificent dividends, could well afford to make the small individual sacrifices which are entailed in forgoing profit on a certain proportion of capital. The Bank of England would publish periodically details of such cash reserves. So much for compulsion. On its part, the Government might well strengthen the Bank by repaying that ancient debt of £11,000,000, on the understanding that the sum should go to the gold reserve.

The chief responsibility undoubtedly lies with those who manufacture credit—viz., the great banking institutions—and it is for the Government to see that they do not fail in their responsibilities. A bank should not be permitted lightly to manufacture currency and credit without backing in a sufficiently substantial manner what it has set up. The shared loss of a few hundred thousands a year, spread over the whole of our banking institutions, arising from the compulsory lock-up of an aggregate of some millions in the form of gold, would leave almost untouched the rate of bank dividends, while it would increase confidence and erect a strong national bulwark against panic.

A GLANCE AT NATIONALISM

The Curiously Contradictory Modern Tendencies Towards an Intenser Local Feeling, and a Wider Union of Allied Peoples

THE PARADOX OF DIVISION WITH UNITY

THE growth from family life to the clan, then to the tribe, and onward to the small homogeneous nation was so natural and inevitable that it does not call for comment. It was made necessary in its first stages by the demands of attack on prey or on enemies, and later by the exigencies of defence against hostile combinations. But as the whole world has become accessible, and the need for stronger federations has made its appearance, a curious paradox has been arrived at, and we see groups of men who have inherited local feeling and tribal pride from many generations massing themselves into larger and larger communities. The old motive of defence is still operative, and necessarily so, in a period when any ambitious people can reach across the world to interfere with the weak. Accordingly, men concentrate into larger empires, but all the while there is no diminution in local patriotism, but rather a growing tendency to preserve ancestral traits. So a curious problem of accentuated division is seen in conjunction with a wider unity. The instinct of nationalism was never stronger than now, when imperialism is equally an active force. Here we wish to look at this paradoxical conjunction chiefly from the point of view of nationalism.

Fifty years ago Germany was an agglomeration of small States, each proud of its separate identity. The tendency to separation, by crystallisation round many local traditions, could not well have been stronger. But now, though the local distinctions are all preserved, and jealousies remain by no means rare, a large fusion on imperial lines has been possible, and shows every sign of popularity. There we get the tendency towards aggregation.

At the same time when Germany was minutely subdivided, Italy was only a name on the atlases. In actual government it was carved into competing sections, with paralysing grounds of contention between them all. Observant people would not have ventured to prophesy for one moment that Italian unity could by any possibility be brought about. Yet Italy is now as homogeneous a nation as any in Europe, notwithstanding the wide temperamental differences between the Lombard and the Neapolitan. The forces of fusion have achieved an irresistible success.

On the other hand, Turkey, in those early days, seemed to have a strongly cohesive power, notwithstanding deeply cleft religious divisions; and now she is disrupted and dismembered, while her component European parts coalesce into small but sturdy nationalities, with dividing jealousies that are only kept in check by detestation of the common enemy.

Again, Scandinavia, bounded, or faced, by encroaching Powers, appeared on the surface to be as natural a unit of national organisation as could be imagined, but it has been split in twain by the fissiparous force of an intense local feeling; and the number of precariously small nations is thereby increased.

In the British Islands there has been a hot and a long-sustained revival of distinctively Irish feeling; while Welsh self-consciousness has kept growing in intensity, though without losing the larger sense of patriotism. How are these contradictory waxings and wanings of restrictive, or of expansive, national feeling brought about?

If all the separate peoples that feel they have an individuality worth preserving were to form themselves into separate communities, for purposes of government and restrictive national association, the number of the world's nations would be doubled to a certainty, and perhaps trebled, or even

quadrupled. What are the influences round which these smaller concentrations have so often taken place?

The chief of them seem to be race, language, religion, identity of interests, and revolt against alien supremacy. The power of race—a common, if far off, ancestral origin—giving to large bodies of men a kind of similar physiognomy of character, has a remarkable persistence. The Jewish type presents itself at once as the most distinctive example, though it has not been helped by the bond of locality for nearly two thousand years, and the race has no organic existence comparable with that of nearly all other peoples.

Is Slavonic or Teutonic Race-Feeling Really Operative?

Even such a vague bond as a Slavonic ancestry is proving a power which politicians regard with much uncertainty. There may come a time when the Slav everywhere accepts the unity of his type as binding, and for a time, or with a purpose, gives race pre-eminence over country. Who knows?

Certainly the Teutonic peoples hitherto have never been in serious conflict with each other. These broad and faint racial divisions seem to have some lasting power. Looking at smaller groupings, who can deny that the influences which keep alive the national spirit of, say, the Welsh are to a considerable extent racial? Unalterable differences of temperament exist, and are never entirely forgotten, on either side of the border.

The Part Played by Language in Building Up Nationality

Often language is in alliance with race; and when attempts are made to work up a sectional self-consciousness in any district the revival of a local language is used invariably as an auxiliary. Thus Welsh more than holds its own in these days of Welsh propagandism, and Irish is making a strong bid for literary recognition. If one wishes for a perfect illustration of the part played by language in perpetuating local distinctions, it can be found among the members of the Austrian Parliament. The instinct of the Boer in South Africa and the French-Canadian in Quebec, in preserving the public use of their languages as a racial heritage, is sound and true.

That identity of language is not essential to the maintenance of national feeling is, however, proved by the case of Switzerland. In no part of the world is patriotism more active, and no nation of the same geographical extent has an equal diversity of tongues. But whether the Switzer speaks French, or German, or the Italian of the Ticino Canton, or the many tongues of the Engadiner, he is not one whit less a proud and contented Switzer.

As for the influence of religion on nationality, it may perhaps be argued that it has more frequently had a disruptive than a uniting effect. Certainly it long distracted Germany and the Netherlands. It failed to prevent the union of Italy in these later days, or to jeopardise seriously the unity of England in Tudor times. But though these illustrations may be given of the occasional ineffectiveness of religion in determining a national trend, there can be no doubt that, on the whole, it has been a powerful national cement—as in the case of Russia—and a predominating influence in Mohammedan lands.

We have mentioned "identity of interests" as one of the formative forces in nationalism, and at some stages in a country's development its powers of fusion are great and lasting.

How Identity of Interests Has Been a National Cement

It brought about the unity of England in the far-off Saxon days, and the unity of Germany forty years ago, as it has made a temporary league in the Balkan region today. It has welded the Scotsman into the commonwealth until he has become an indistinguishable Britisher; and it is obliterating all European nationalities in the United States, and making a conglomerate nation whose new component members only calculate—after a few years—how well off they are.

The last influence we have mentioned as contributing to a sense of nationality—namely, the revolt against supremacy being assumed by other people—is one of the most potent. Nothing brings separate nationality into life and vigour so readily as attempts to stamp it out. Probably the Jews are as much indebted for their marvellous persistence to the persecution they have undergone century after century as they are indebted to their native tenacity. The one has produced the other, in a people driven in on themselves by omnipresent tyranny. Look where we may, we find the attempts of alien people to crush their neighbours, or conquered communities, resulting in the preservation and ultimate revival of sectional aspirations and ancestral traditions.

Take a few illustrations. The presence of the Spaniards in the Low Countries was

the spur that there kept alive and eager the sense of freedom, and led eventually to the formation of modern Holland. The attempts of Europe to coerce France at the end of the eighteenth century—largely a dynastic movement—caused French national feeling to reach the fever-heat that started Napoleon on his conquering career. And, as he trampled country after country underfoot, he, in his turn, aroused on every hand a sense of nationalism that was not dynastic merely, but that sprang up spontaneously in the hearts of the people, till, with one consent, they "shook the spoiler down," and modern Europe, with its many strong examples of national consciousness, came into being.

At the beginning of the nineteenth century no country in Europe was more deeply sunk in sloth, or more effete, than Spain, and on her Napoleon practised the worst of his treacheries; but from her weakness she sprang up into a passion of patriotism that proved to be the beginning of the oppressor's downfall. In the same way the Corsican adventurer relit the love of country throughout Germany, in Austria, in Russia, and even in disputatious England.

Oppression as a Means of Evoking Slumbering National Feeling

More recent evidences abound in proof of the power of domination to create and sustain an unending opposition, and to prevent the fusion of different racial sections into an empire that cannot avoid constant irritation. If ever people can be made susceptible to crushing and cowing, the policy must have succeeded in the cases of the subject peoples of Turkey. The Bulgar, the Serb, the Macedonian, the Armenian—what a wide practice ground the Turk used for his system of "thorough"! But government by extortion, under terror of massacre, having done its perfect work, the subject races all rise into national consciousness, and a freedom that, once felt, no power can ever again circumscribe. If there is in European Turkey something like a plethora of nationalism we need not wonder at it, seeing how drastic were the methods which evoked it.

What has happened in Turkey is but a repetition of the experience of Austria. She forced her supremacy on the land now called Switzerland until she awoke a local patriotism that has never died out, and that now commands the admiration of the world long after it has rid itself of fears of invasion. It was largely Austrian domination that called Italy to a complete unity; and the French occupation of Rome lost the Pope the secular possession of the Eternal City. The same lessons may be read nearer home. Great Britain has had experience in government far beyond that of any modern nation, and has succeeded under remarkably diverse circumstances, but sometimes she has failed, or come near to failure; and in all such cases it has been when she has thrust an irksome supremacy on an unassenting people, thereby arousing and sustaining a sense of resistant nationalism. In that spirit she lost the American States, has kept Ireland gravely dissatisfied for more than a century, and has allowed Welsh sentiment to concentrate on a grievance.

The French-Canadian Example of Wisely Tolerated Difference

On the other hand, examples may be quoted of the continued existence of local patriotic groupings, due to race, language, religion, or topographical pride, with firm adhesion to a wider patriotism of an imperial nature. The French-Canadians and the Tyrolese are outstanding examples. By a wise reading of what is due to perfect liberty, the British Empire has left the French-speaking parts of Canada, peopled by a French stock, in complete possession of all their distinctive rights. Their language ranks with English in the courts and the Parliaments of the Dominion. Their racial susceptibilities and religious loyalties are treated with delicate consideration. The result is that in no part of the British Empire is participation in its vast alliance more valued, for the French-Canadian knows that nowhere else—not even under the American Republic—would he enjoy an equal degree of freedom, and free play for individuality.

The Free Bond that Has Held Tyrol to Austria

Perhaps even more striking is the position of Tyrol in the Austrian Empire. For five hundred years this mountain people has been faithful to the Austrian Crown, though one might well suppose it would have sought a separate existence because of the clear definition of its nationality. The Bulgar, the Serb, the Albanian, the Montenegrin, the Roumanian, is not one whit more a small type apart than the man of Tyrol. Yet the Tyrolese have never resented association with Austria, and have only combined nationally on their own account when Austria had deserted them, under pressure by Napoleon.

Later, they returned cheerfully to their old allegiance. Indeed, the drawback to our admiration of them is that their unbroken loyalty to Austria caused them to be willing instruments in the oppression of other mountain peoples who were longing to be free. The reason is to be found in the consideration shown for them nationally by the Austrian Crown, and their direct association with the Empire in freedom and with no sense of servitude. They have never been driven to a defence of their individuality, yet it has existed in fullest force.

Some Instances of Complicated National Feeling with a Double Loyalty

If we glance round the world we shall see that there is a great deal of what may be called smaller nationality existing, more or less distinctively, underneath a broader sense of country. Thus the Chinese not only have their racial differences with the Manchus, but also are divided into Northern and Southern sections of unknown cohesion; but it now seems that over all there may extend an inclusive patriotism, even when the oldest and most binding form of government has unexpectedly failed. India is a mere geographical name for innumerable races and local loyalties, all of which find a common centre in the British "Raj"; and round that central idea there has grown up a form of devotion which, one would fain believe, is not wholly a product of self-interest. A curious example of independent yet contributory nationality is seen in Nepaul, a very exclusive country that carefully holds aloof in many ways, and is tenacious of its rights, and yet supplies the native army of India with a continuous stream of its best fighters—the Goorkhas—though there is no obligation to do anything of the kind. The faithful Goorkha is indeed a perfect example of a loyalty within a loyalty, the two claims being quite distinct. Happily, it is long since they conflicted.

The Pathos of Peoples Who Would Be Nations, but Never Can Be

In some cases the sense of nationality persists in a kind of lost and hopeless way long after there is any rational hope of full expression, and when a realisation of vague local hopes would certainly have fatal effects. Thus, cleverly as the dismemberment of Poland was effected, leaving the Polish race without a vestige of hope in the midst of Powers overwhelmingly strong, the spirit of independence has not wholly died out. In another instance, under the fostering care of the British, that spirit has even revived in the Egyptians, a race of long-proved incompetence for government, that is seated in a part of the world where strength is the first demand. Egypt has been overrun from time immemorial by more vigorous races, and within comparatively recent memory would have been blotted out by barbarism but for the intervention of the British, who have given safety and a long unknown prosperity to a land which is one of the world's natural thoroughfares. Yet there are Egyptians who would risk the obvious calamities of an impossible independence, misled by hopes fed from far-off history. These longings are a part of the pathetic ineffectuality which has so long left Egypt a prey among the nations.

So far we have been commenting upon that sense of nationality which struggles into existence, or keeps itself distinct, under adverse circumstances, and shows the beginnings of the aggregatory instinct; but, as a rule, the modern nations are examples of the welding into a new patriotism of the fragments of older and smaller patriotisms.

The Formation of Great Peoples from Many Dissimilarities

Every great nation is a conglomerate structure. The people living in our country twelve hundred years ago could not have conceived what we now mean by the words Englishman, or British. The deep tribal and racial differences of those days have been rubbed away as the granite mountains of old are denuded into rounded tors of no great elevation, and persist only in local physiognomy and provincial dialects. It is the same in France. The Frenchman of the Vosges is as far apart from the Breton of Morbihan as the fenman is from the Cornishman. The Norman and the Gascon are, and always have been, as distinct as the peasants who slur their speech in Dorset, and burr it in Northumberland; and yet a common patriotism has swept over these lands, more widely distant in human temperament than in geographical space. In each of these cases the building up of the modern homogeneous nations was slow, but there are examples of very rapid consolidation.

We have seen Russia extend her boundaries south and east, and gather in races as diverse as the Circassian mountaineers, the Georgians, the men of Bokhara, the agriculturists who are making Siberia to blossom like Sharon, and the Letts of the Baltic, and, with the exception of the Finns, who are isolated by a superior edu-

cation as well as by racial differences, they all seem to be bound together by a useful it not very enthusiastic patriotism. Disloyalty in Russia is directed not against the national idea, but against forms of government which are regarded as faulty and temporary.

German patriotism, as it is concentrated on the rule of the Kaiser, rather than that of the subsidiary monarchs, is a more remarkably rapid growth. Up to the time when the exigencies of the personal rule of the Third Napoleon, played on cleverly by the craft of Bismarck, flung France and Germany against each other in war, there was doubt as to the part that would be taken by the South German Confederation. Germany was firmly welded by pressure from without, just as the British Empire is being welded today. It is a matter of common observation that within the German Empire are the most pronounced and, indeed, antagonistic dissimilarities. Between the expansive and artistic Bavarian and the rigid and repellent Prussian, who still seems to be ruled by the rod of Frederick the Great, there is a wider breach of sympathy than between the dourest Lowland Scot and the most fluent and genial Irishman, yet the wide call of the Fatherland gathers them both into one fold, with a sincere patriotism.

How far the agglomeration of peoples that make up the United States of America has resulted in the production of a nation devoted to the Republic, as a land, has not yet been tested, though, no doubt, the American born of, say, two generations is intensely loyal, and is fully alive to the need for uniting the incoming people of all races in a new national pride. But does the emigrating German ever cease to be a German and become an American instead? Is the Norwegian anything but a transplanted Norwegian? To what country does the New Orleans Italian really belong? These are questions that have never been put to a practical test; but however they may be answered they do not alter the fact that the United States have formed a new patriotism in a wonderful way, by a kind of self-conscious manufacture through their schools. They have had no concentration through the pressure of external danger, as is often the case with Continental nations, and none of the incitement of special

ROUGET DE LISLE SINGING FOR THE FIRST TIME THE WONDERFUL NATIONAL SONG OF FRANCE, THE "MARSEILLAISE," WHICH RAISED AND TODAY INSPIRES THE NATIONAL SPIRIT OF THE FRENCH

enterprise that comes to such a nation as Great Britain, whose dealings necessarily are with all the world, and whose difficulties are correspondingly wide and varied. The American people have set themselves to be patriots, and, no doubt, their incessant talk of it, particularly during the susceptible years of youth, has had its effect, and the born American "Hails Columbia!" with an exceptional, if carefully trained, fervour. But there are many new-comers who must be allowed time to learn, if they ever learn, what it all means.

The Great Recent Growth of Conscious National Feeling in the British Empire

It is in the British Empire, however, that the most striking example of an all-embracing nationalism is seen, with free allowance for more local patriotism. An extraordinary concentration has taken place within comparatively recent times, stimulated partly by the South African War, with its proofs of a world-wide British unity, and its undercurrent of suggestion that jealousies were stronger outside the Empire than friendships. Each important part of the Empire -Canada, Australia, South Africa—has become federated, and each is linked afresh with the Mother Country, and with the rest. The growth of a new imperial consciousness has been rapid and firm. It was always latent; it is now visible and explicit. Through the schools, by the use of national symbols, and by the beginnings of national training in "fit" manhood, the sense of nationality has been evoked. But the underlying principle has been that of "Live and let live." We are determined to live as a great and beneficent people. We equally see the justice of letting other nations live and work out their peaceful destiny. In this unaggressive sense the organisation of national feeling has proceeded apace, and there is reason to believe that its appeal to legitimate, but not overbearing, pride has been felt through all the differences of colour and lineage that are represented in the Empire, and that loyalty to British ideas and aims is not confined to British stock.

What Gain Does a Sense of Nationality Bring to the World?

What is the use in the world of the sense of nationality that is so widely displayed and so passionately cherished? Is not the biological use of it found in the fact that progress comes through variations from an even type, and a sentiment of nationality tends to preserve individuality, or human variations, so that each may contribute something special to the race? Every district within a nation plays its separate part in this sense, and the whole nation accentuates some human qualities that cannot be spared. Who would miss French *élan*, or German thoroughness, or American confidence, or English self-satisfaction? It is the national individuality that all instinctively defend, and that all should all instinctively respect.

Why some people should be so proud of their country is a mystery to others, except that the country is the only place the defenders know. The most desperate resistance to the conquest of England was offered by the denizens of the ague-stricken fens. It is equally inexplicable why the Albanians resent so sternly any intrusion on their barren mountains. But, on the other hand, there are nations in whose heritage is involved the hope of the world, as in the case of England, through whom has come to mankind God's new Messiah, freedom.

The Nobility of the Finer Phases of Patriotism

And however and why ever a sense of nationality or a love of country comes to men it lifts them clear above the plane of selfishness, and endows them with a devotion that may not be understood, but certainly is altruistic. It is not the dog-like fighting instinct in man that makes him patriotic, though that may play a secondary part. That would not fill his eyes with tears as he looks on his nation's flag abroad, and hears the hymns of his country. The sublime sacrifice of each man for all men is reached in patriotism, and the human heart knows nothing nobler. And in proportion to the greatness of this passion is the evil of using it to fulfil an aggressive ambition, personal or national.

In recent times one supreme instance has been shown to the world of the power of patriotism acting on the highest level, and in a multiplicity of ways; but the Japanese nation has adopted deliberately love of the State and its ruler as a part—perhaps the most tangible part—of its religion. In loyalty to that idea, and trusting their advisers, the people changed their form of government, their national ambitions, and much of their outlook on life. This new national policy of the Japanese, carried to success, promptly and completely, in the arts of peace and science as well as war, stands as an example of national self-realisation unparalleled in the world's history.

ALCOHOL AND PARENTHOOD

The Many Forms of Sacrifice of Childhood Through the Drinking Habits of Parents

FINAL TRIUMPH FOR THE SOBER RACES

We dealt, in the last chapter, with the evidence respecting alcohol as a racial poison, which may damage the very germ-plasm of the race. That, however, is only a part, though a primary part, of the more general question of the influence of alcohol upon the whole of parenthood. In the present chapter we try to summarise the facts, in regard to aspects of parenthood—beyond the sheer initial production of the germ-cells—upon which the nurture of the next generation, and even its survival, largely depend.

First, as to the destruction of fatherhood by alcohol. If such destruction can be demonstrated, we must estimate, if we can, what influence it will have upon the nurture of the next generation, considering what provision usually exists, in our society to-day, for the care of children of widows. How many widows and orphans does alcohol make ?

Numerous inquiries at home and abroad agree somewhat closely in stating that 14 per cent. of the entire death-rate is due to alcohol. The proportion of one in seven is generally accepted, even by ardent defenders of alcohol, such as Mr. Archdall Reid, and the justness of this figure is not likely to be disputed, except as an under-estimate. We are here dealing with male deaths only. Taking the figures for 1906 for England and Wales alone, we have 167,307 deaths of males over fifteen, 23,422 of these wholly or partly due to alcohol, and of this number 12,554 were married men (*i.e.*, 536 per thousand). The average size of a family in England and Wales was given by Whittaker in 1908 as 4·62. If we leave out the father it is 3·62, and if we multiply the number of widows, 12,554, by 3·62, we shall have an approximation to the number of widows and orphans made by alcohol in 1906. There were 45,445, or over 124 widows and orphans made by alcohol every day in the year. If we availed ourselves of the figures in the census of 1911, it could be readily shown that these figures are much too low, because they do not reckon with the height of the birth-rate in the classes from whom the alcohol-made widow is mostly recruited.

Dr. Tatham's figures—in his official "letter to the Registrar-General"—derived from his observations on occupational mortality for 1900, 1901, and 1902, show us where this destruction of fatherhood mostly occurs. Thus one may note such occupations as coal-heaver, coachman, cabdriver, groom, butcher, messenger, tobacconist, general labourer, general shop-keeper, brewer, chimney sweep, dock labourer, hawker, publican, inn and hotel servants. A glance at Dr. Tatham's tables will show that in most cases the men who are dying are "industrial drinkers," who frequent public-houses in just those districts where, by general admission, public-houses are too numerous. Often nowadays the widows are heavy drinkers, and the lives of the children whose fathers have already been destroyed by alcohol centre round the public-house. We have already looked at the microscopic and the genealogical evidence which shows how alcohol, under certain conditions of dilution and of time, may injure the germ-plasm of the father, and now we observe that it frequently destroys him altogether, leaving the nurture of his children to such conditions as we are content to provide today for our childhood—the only kind of absolute wealth by which any nation can survive.

We must now proceed to observe the special relations of alcohol to motherhood; for while this drug can affect the offspring in only two or three ways through the father—the two we have noted already, and the

third way of making the father inflict cruelty upon the children—it can strike at the children in more ways through the mother. In the first place, it affects the child's ante-natal nutrition. This fact can no longer be disputed, it having been proved by chemical analysis, as Dr. J. W. Ballantyne points out in his great work on "Ante-Natal Pathology," that the drug enters the body of the child. We saw the same with lead; and it has been chemically demonstrated with both poisons in the lower animals. Now, if alcohol is admittedly injurious to infants, which no one questions, it must be injurious when the nervous system is even younger and more susceptible than it is in the infant that we know.

The most careful and detailed inquiry on this subject was made several years ago by Dr. W. C. Sullivan, the distinguished medical officer of Holloway Prison. He found, in the first place, when studying the motherhood of 120 drunken women, that of 600 children who had been born to them, 335 (58 per cent.) were still-born or died in infancy. Now, many of these women had female relatives of sober habits; and Dr. Sullivan therefore thought that it might be worth while to compare the death-rate among the offspring of the sober mothers with that among the offspring of the drunken mothers *of the same stock*.

The Appalling Death-Roll of Children with Drunken Mothers

The result of this comparison was most remarkable, though not unexpected. Dr. Sullivan found that the ratio of deaths among the children of the sober and of the drunken mothers respectively was as 23·9 to 55·2. In other words, the death-roll among the children of the drunken mothers was nearly two and a half times as high as among the children of the sober mothers *of the same stock*. We may be grateful to Dr. Sullivan for this comparatively early inquiry of his, and for his wisdom in comparing children of the same stock.

One other fact Dr. Sullivan also observed. It consorts with expectation, also. In the drunken families there was a progressive rise in the death-rate from the earlier to the later-born children. This agrees with what Dr. Welsh Branthwaite and others have observed in the case of the female inebriate—that, at last, she can no longer become the mother of living children. Probably in these cases we have the visible correlate, in terms of children, of what Bertholet discovered in the microscopic characters of the alcoholised germ-plasm, which goes from bad to worse under the continued action of the poison.

It was admitted many years ago by Mr. Archdall Reid that drunkenness on the part of the expectant mother really involves the intoxication of two individuals, and various observers have witnessed the birth of children that were under the toxic influence of the drug when they were born. In some cases the liquor taken by the mother has been smelt in the new-born infant's breath.

But we may pass on to the next question, if we avail ourselves of the summary of the evidence regarding alcoholism in the expectant mother which was contributed by Dr. J. W. Ballantyne to the first National Conference on Infant Mortality in 1906, and which has been further confirmed since that date. This first living authority on the subject then wrote as follows.

Disastrous Ante-Natal Consequences of the Intemperance of Mothers

"It must then be concluded that parental and especially maternal, alcoholism, of the kind to which the name of chronic drunkenness or persistent soaking is applied, is the source of both ante-natal and post-natal mortality. It acts in all the three ways in which I showed that ante-natal causes can be shown to act in relation to the increase of infantile mortality—viz., by causing abortions, by predisposing to premature labours, and by weakening the infant by disease or deformity so that it more readily succumbs to ordinary morbid influences at and after birth. By causing diseases of the kidneys and of the placenta it also leads to that failure of the filter to which I have already referred; the placenta being damaged, not only does the alcohol more readily pass through it itself, but it is also possible for other poisons, germs, and toxins to cross over into the fœtal economy. So it comes about that the most disastrous consequences are entailed upon the unborn infant in connection with syphilis, lead poisoning, fevers, and the like in the intemperate mother."

The Terrible Mistake of Giving Alcohol to Expectant Mothers

The astonishing power of the placenta in acting as what Dr. Ballantyne calls a filter of the maternal blood, so that most poisons are forbidden to enter the blood of the unborn child, fails in just a few cases. Of these, alcohol and lead are the most conspicuous; and Dr. Ballantyne has shown that perhaps the worst fact about alcohol in such cases is that it breaks down the resistance of the filter to other injurious

THE MUTUAL DUTY OF THE WIDOW AND THE WORLD—"THE WIDOW'S MITE," BY DUBUFE

substances which may occur in the blood of the mother. It need hardly be said that, in the light of our present knowledge of this subject, no doctor can *ever* be justified in prescribing alcohol for the expectant mother. Even if we had no records—and we have many—of cases where such prescription, at such a time, has led to the formation of a ruinous habit, we should be forbidden to prescribe this drug now that we know that, when we do so, we are alcoholising the unborn infant. No form of alcohol, overt or covert, no so-called tonic wines, no digestive wines, none of the popular drugs which depend for their murderous success upon the alcohol they contain, can be permitted for the expectant mother if she would do the best for herself and for the race.

The Loss of Power to Nurse Children Through Parental Alcoholism

Let us now consider the nursing mother. But before we ask how alcohol affects her functions, we must consider a celebrated piece of investigation undertaken some years ago by one of the greatest Continental students of drugs, Professor von Bunge, whose name is known to all therapeutists, and especially in connection with his researches on the medical properties of iron. Briefly, von Bunge found that, according to his statistics, the daughters of alcoholic fathers had lost the power, or were without the power, of nursing their children. Von Bunge believes that the paternal alcoholism has acted as a racial poison in the specific and remarkable way, above all, that the female offspring are naturally deficient in the function of lactation. These conclusions have been disputed; and undoubtedly the data are not conclusive, because recent evidence seems to show that large numbers of modern women—especially, perhaps, in cities—have lost the power to nurse their children. There are other subtle factors at work, of no mean potency, and therefore we have to ask what part they played in the results which Professor von Bunge observed.

The Poisonous Action of Alcohol on the Mother's Milk

We are on surer ground when we come to the simpler question—How does the taking of alcohol by the nursing mother affect lactation? The simple fact is that, in her case, there is an exceptional avenue for the excretion of the poison, in addition to the lungs and the kidneys and the liver, which exist in everybody and set to work directly alcohol enters the blood. To these, therefore, the blood of the nursing mother adds the breasts; and chemical inquiry has shown that alcohol can be traced in mother's milk within twenty minutes of its entry into the stomach, and may be detected in it for as long as eight hours after a large dose. Many cases are on record where infants at the breast have thus become the subjects both of acute and chronic alcoholic poisoning. We have numerous reports of convulsions and other disorders occurring in infants when the mother or foster-mother has taken alcohol and ceasing when she has been put on a non-alcoholic diet.

Mrs. Mary Scharlieb, the most distinguished obstetrician in this country, and recently President of the Obstetric Section at the meeting of the British Medical Association, says in this connection, "The child, then, absolutely receives alcohol as part of his diet, with the worst effect upon his organs, for alcohol has a greater effect upon cells in proportion to their immaturity." Further, as she points out, "The milk of the alcoholic mother not only contains alcohol, but it is otherwise unsuitable for the infant's nourishment; it does not contain the proper proportions of protein, sugar, fat, etc., and it is therefore not suited for the building up of a healthy body."

The Delusion of an Increased Milk-Flow Through Taking Alcohol

We can therefore come to a definite decision on the question whether the nursing mother owes the taking of alcohol as a duty to her child. She may be a teetotaller; she may fear to take alcohol; and she may be told by a doctor that it is her duty to do so, because the quality of her milk will be improved. In such a case she may yield, though often with a wry face, and thus we frequently have the beginning of disasters to which there is no end. The truth is that the medical profession has long erred in this respect. Judgment has gone by a misleading sign. Undoubtedly there is a greater bulk of milk when stout and porter are taken, but everyone knows that ordinary household "milk" may come from the cow or from the pump. The question is not the bulk of the milk, but the constitution of its bulk. Definite chemical evidence, which may be repeated *ad infinitum*, and which is allowed to go un*challenged (and unheard-of) by* the many doctors who are prescribing alcohol for the nursing mother all over the world, proves that its influence is to increase the bulk of

the milk while reducing the amount of its nutritive constituents, and adding to them one which is poisonous. Doctors look back a hundred years or so, and observe the amazing practices of their predecessors. They have records of prescriptions and treatments which were disgusting or ridiculous or painful or trivial; they have abundant record of practices which were deadly, and for which any medical man at the present day might be called upon to pay heavy damages or be indicted for manslaughter. Here, as another twenty years will declare without question, is another such. Those who now condemn it earn similar thanks to that which the critics of past malpractices earned, bnt they will have their way.

Only one further observation is necessary. If a diet is wanted which shall aid in the formation of milk, let us choose one containing compounds which can be built up into one or more of the food-constituents of milk. That seems reasonable enough. It is the chemical fact that alcohol cannot be built up by the body into protein, fat, sugar, or salts. The thing is chemically impossible. The best foods for the making of milk are milk itself—who would have thought of that? -and bread and butter and meat. These not only make milk, but they make milk that is worth drinking.

We must observe here how small a part mere drunkenness—*i.e.*, acute alcoholic intoxication—plays in this question. It was always an error to suppose that gross drunkenness was the whole of the evil done by alcohol, and now it is more an error than ever, for drinking among women increases, and it is not the form of drinking that most frequently leads to drunkenness. In the case of women, the very obvious and natural tendency is for the proportion of drunkenness to the alcohol consumed to be much lower than in the case of men. Drunkenness is commonly the result of convivial drinking. A company of men get together and they help each other to get drunk. Women are not subjected to so many temptations in this respect. Their drinking is not "convivial drinking," but "industriai drinking"—the important distinction is Dr. Sullivan's—and, above all, since "a woman's work is never done," and since her chief industry is the supreme industry, the culture of the racial life, her drinking must be disastrous. Except in the special class of the feeble-minded inebriate, drinking among women is less conspicuous than convivial drinking, it leads to few arrests for drunkenness, but it has far graver effects on the individual, and it shows its consequences in the industrial product, with which in this case no other industrial product can compare. Unless we disabuse ourselves once and for all of the notion that the drink question is merely a drunkenness question, we shall never succeed in understanding the real significance of what we have here called the *one* ominous fact in our national drinking habits.

MRS. MARY SCHARLIEB

Dr. Sullivan writes with such high authority and wide experience, always having large numbers of inebriate women under his care at Holloway, that we cannot do better than quote two paragraphs from his small but invaluable book on "Alcoholism."

"The domestic occupations which are the chief field of women's activities obviously allow ample opportunity for the continuance of alcoholic habits formed prior to marriage. This is a matter of much importance. For the ordinary existence of the working man's wife, with its succession of pregnancies and sucklings, and the management of a brood of children in cramped surroundings, will of itself be very likely to promote tippling; and if a knowledge of the effect of alcohol as an industrial excitant has been acquired by the factory girl, it is pretty sure of further development in the married woman. Instances of this sort, in which the discomforts of a first pregnancy stimulate the growth of a

rudimentary habit of industrial drinking to confirmed intemperance, are tolerably common in any wide experience of the alcoholic. The employment of women in the ordinary industrial occupations not only involves a disorganisation of their domestic duties if they are married, but it also interferes with the acquisition of housewifely knowledge during girlhood. The result is that appalling ignorance of everything connected with cookery, with cleanliness, with the management of children, which makes the average wife and mother in the lower working class in this country one of the most helpless and thriftless of beings, and which therefore impels the workman, whose comfort depends on her, not only to spend his free time in the public-house, but also tends to make him look to alcohol as a necessary condiment with his tasteless and indigestible diet. Both directly and indirectly, therefore, the employments that withdraw women from domestic pursuits are likely to increase alcoholism, and, it may be added, to increase its greatest potency for evil—namely, its influence on the health of the stock."

How Drunkenness May Make the Mother an Unconscious Murderer

We have now considered the three *organic* relations of alcohol to parenthood—as a racial poison, during expectant motherhood, and during suckling. But parental alcoholism is still liable to injure the offspring, though none of their own tissues are touched or affected by the drug. The fact of overlying may be briefly referred to, with its notorious dependence upon maternal drunkenness in almost every case. The healthy mother's brain will hear and feel the cry and the movements of her infant, when she is pressing too hard against it in her sleep, and she will wake and save the child. The intoxicated brain and subconscious mind cease to exercise that maternal watch which, normally, slumbers not nor sleeps, and the child is suffocated by the weight of the mother who bore it. Under the Children Act it is hoped that these cases may gradually diminish in number, as in Germany, where a law which recognised the culpability of the mother practically abolished cases of overlying.

Next in logical order comes the question of parental cruelty to children, together with the cruelty which children suffer from "guardians" who are not their parents. Readers of a very admirable and exact inquiry, made on true scientific lines by Mr. G. R. Sims, and recorded in his book "The Black Stain," are aware that he found alcohol to be *the* cause of cruelty to children in this country. Probably 90 per cent. of all cases of persistent cruelty to, and neglect of, children are due to this cause. The testimony of the National Society for the Prevention of Cruelty to Children, and a host of other testimony with the same authority, is the same.

Alcohol the Child's Worst Enemy Throughout the Civilised World

The total indictment is thus a formidable one. So many and various influences are at work, before birth and after it, to injure the children of alcoholic parents, by "nature" and by "nurture," that the numerous inquiries which have been made into the condition of such children are only too completely explained. The results are the same, whether observed in Switzerland by Forel, in Finland by Laitinen, or in New York, where fifty-five thousand school children were studied, a few years ago, for the elucidation of this question. On the whole, and surveying the civilised world at large, we cannot doubt that alcohol is the worst enemy of parenthood.

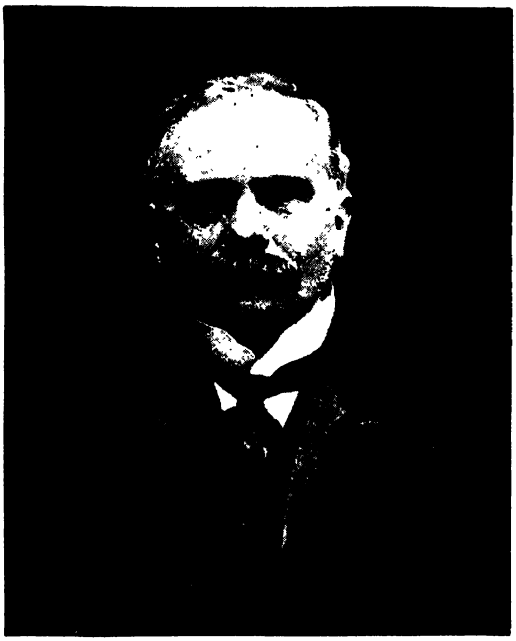
Unfortunately, it is still necessary, and will be so for a little time to come, to refer to the single and notorious exception to the results which students of this subject have obtained everywhere—the report published by Professor Karl Pearson in May, 1910, and entitled "A First Study of the Influence of Parental Alcoholism on the Offspring." The demand for the withdrawal of that report has been publicly made in the "British Medical Journal" and elsewhere.

A Notoriously Misleading Study that Should be Withdrawn

Until that demand is complied with, the conclusions of the report will continue to be quoted and reprinted and distributed by those who are interested in the sale of alcohol; and therefore it is necessary once again to point out, as briefly as may be, the causes which led so distinguished and skilful a mathematician, when making what was obviously his "first study" of a very difficult subject, to conclude that the children of the alcoholic parents whose statistics he studied were, if anything, superior on all counts to the children of the sober parents.

The essential criticism is that the authors had no information, in any case, as to whether the parental alcoholism, the influence of which upon the offspring they expressly set themselves to examine, *occurred before or after the birth of the offspring!*

Obviously, no further criticism is required; the report ceases to have any relevance to the subject which it professes to discuss; but we may go on, as the fallacies of this report help us to realise the conditions under which future inquiries into similar problems must proceed if they are to be useful. The report dealt with only two generations, though it is as long ago as 1865 that Mendel showed to the unseeing world how we must study at least three generations if we are ever to learn anything about heredity. The report confounded different stocks, a cardinal error which, as every modern student of genetics knows, must vitiate any inquiry. The report did not compare comparable parents—an obvious necessity for just comparison between their children, as Professor Pearson himself admitted in defending this report in the "British Medical Journal." The report did not even try to compare the children of abstainers with those of drinkers, for the abstaining parents were so few in the population which the report studied that they were "slumped" with the so-called moderate drinkers. The report used no criterion of "alcoholism," but grouped all cases, without inquiry, including those where non-medical visitors had merely noted that the parents were drinking more than was good for the home!



DR. J. W. BALLANTYNE

Photograph Swan Watson

Most remarkable of all, perhaps, is the nature of the material from which the statistical data used by Professor Pearson were drawn. He believed, and afterwards asserted in controversy with Professor Alfred Marshall, the famous economist, in the *Times*, that he was dealing with quite a normal sample of the working-class population.

The whole argument admittedly would fall to the ground unless the parental material, so to call it, could be assumed to be a "normal sample," except where and as alcoholism affected it. But actually, though the fact was not published till the practical end of the controversy, in the following February, the Edinburgh material, used by Professor Pearson as a normal sample of the working-class population, was actually derived from the North Canongate slum of Edinburgh. The fact was not known to Professor Pearson, of course, as the name of the school whose children were described was mercifully suppressed in the schedule from which he took his data. Needless to say, Professor Pearson had not been to see any of these Edinburgh children, or their parents. He studied them from London.

Professor Pearson's "normal" children were from the very slum which was first studied by Dr. Leslie Mackenzie, after the Boer War, at the request of the Commission appointed to study the facts revealed by the condition of recruits and would-be recruits during that campaign. So terrible were the facts of this degenerate population, and especially of the children, that other cities were studied also; and from the facts thus ascertained directly developed the system of medical inspection of school children, and the entry of the doctor into the school. It only remains to repeat here, in the name of truth and science, the demand for the public withdrawal of this overwhelmingly discredited report, the most signal and tragic instance within recollection of the miscarriage, through ignorance and over-confidence, of sincere intention and patient labour.

When we survey the now demonstrated action of alcohol upon the racial life, it begins to be more and more clear that this drug may have played and may be playing a great part in the history of mankind. As the "history" we learnt at school is more and more discredited, there is slowly coming into being a real kind of history which deals with the essentials of national life and death. Our modern study of certain diseases and poisons begins to throw a light on the life of nations. We have

seen what some recent students believe of malaria and its influence upon the history of Greece and of Rome. In the case of alcohol we now have definite and final evidence. The properties which it displays when we study it today have always been and always will be its properties. As we study under the microscope the influence of alcohol, we begin to see that its influence on parenthood may have been one of the greatest facts of history.

The Persistence of the Jews Dependent Partly on Their Immunity from Alcohol

The immunity of Jewish parenthood from alcohol may be one of the great factors that explain the unparalleled persistence of the Jews, their survival of all their oppressors, and their present status in the van of the world's thought and work. This argument was advanced by the writer, some five years ago, in his lecture at the Royal Institution on "Biology and History," and he believes its truth to be more probable in the light of the evidence gathered since that date.

For history it is the parents that matter as against the non-parents, and of the parents it is the mothers even more than the fathers. The freedom of the Jews as a whole from alcoholism is more marked than ever in the case of their women—that is to say, in the case of their mothers.

The emergence of hitherto sober nations, such as Japan especially, into contemporary history, and the possibilities latent in China—to mention none other of the "dying nations" so very much alive, at whom some politicians used to sneer—is the major fact of contemporary history. No one can yet say whether these nations will have the wisdom to retain their ancient habits, or whether they will accept our whisky along with our Parliamentary institutions and motor-cars. Much future history rests upon this issue.

Racial Predominance in the Future Partly a Question of Sobriety

Observers in New York and London say that, under modern conditions, the younger Jew is beginning, slowly but definitely, to imitate his neighbour's habits, and that drunkenness, even, may be recorded in two or three Jewish cases in those cities. It is an ill omen, if the records of the past may be trusted. As for Japan, there seems to be no question that alcoholic intoxication is rapidly becoming commoner there under the influence of European civilisation.

The pressure of population, as was said in this section long ago, is the irresistible force of history. It depends, of course, upon parenthood, and especially upon motherhood. At present the motherhood of the yellow races is, on the whole, sober. If it remains so, and if the motherhood of Western races takes the course which motherhood has taken for many years past in England—and which it has recently begun to take, with tragic speed, in new industrial Italy—it is very sure that, in the economic or military Armageddon of the future, those ancient races, Semitic, Turkish, Mongol, or whatever they be, which had achieved civilisation when Europe was in the Stone Age, will be in a position of immense advantage as against even our own great race, which threatens, at any rate in the heart of the Empire, though certainly not in the Colonies, to follow the example of many races of which little record, or none, now remains, and drink itself to death.

The Education of Adolescence the Secret of Successful Combat with Racial Poisons

The best forces of our time will surely avert that end. The conditions of motherhood in the teeming and prolific centres of our industrial life cannot much longer be permitted to endure. Now that the existence and the action of the racial poisons, and especially of alcohol, have been demonstrated, so great a nation as ours, so rightly proud of its history and its potential destiny, cannot fail to deal with them. All the signs, in regard to the national consumption of alcohol, are propitious save this one—that the young mothers are learning to drink, and that, while industries that are worth nothing in themselves thrive, the one industry of race-culture, whose product all other industries exist to serve, is threatened.

There are various legislative possibilities, of critical and current interest, which will fall to be considered shortly. But the fundamental need for the fight against the racial poisons is the education of adolescence.

In 1871, at the dawn of national education, Ruskin wrote that the idea was all right, "if only we determine also what kind of education we are to have." After forty years of trying to do without any ideas as to what we should teach our children, we begin to find it experimentally proved that he was right. The next step will be to teach them first things first—and then, or by no means, all other things may be added unto them.

A SECRET UNIVERSAL PLAN

The Watchings, Calculations, and Inferences by which Men Try to Find a Harmony of the Spheres

MOVEMENTS AND DISTANCES OF STARS

In all its main features, the map of the heavens remains the same throughout the centuries. It becomes more thickly strewn with small celestial objects as these are discovered with improved instruments; but for the ordinary observer, who looks at the stars with unaided vision, they present virtually the same appearance as they did thousands of years ago to the earliest astronomers. The great constellations and the familiar individual stars shine for us exactly as they did for prehistoric man.

Yet the fact is that all the stars are in perpetual motion, and their relations undergo incessant, gradual change. The study of these changes is perhaps the most difficult branch of astronomy. In following the progress of the physical development of stars we have found the history to be full of gaps and uncertainties, but the subject is yielding fruitfully to more and more searching investigation. But the study of the real motions of stars, and of their distances, on which our knowledge of their motions depends, is far more baffling. The difficulty arises chiefly from two causes—the immense actual distances of the stars, and the absolute lack of any fixed reference-points by which to measure their movements. In the latter difficulty we are ourselves implicated in a degree and in modes which are as yet unascertained. Our sun is one star among millions, and, like all the rest, he is in constant progress through the heavens, though we have no certain knowledge concerning this progress. For all we know, he may be also implicated with other unrecognised stars as members of a group or system with common motions, and in permanent relations. No evidence of such relations has as yet been discovered, but that is no proof that they do not exist.

The motion of the earth round the sun, and its daily revolution about its own axis, cause an apparent processional movement in the whole universe of stars. The constellations rise and set at different times according to the time of year, and must be looked for in different places according to the hour and season. These apparent motions are familiar to all of us in a general way, and have been actually known and recorded as long as the stars have been studied at all. Their rising and setting and position in the heavens have from time immemorial connected certain of the stars with different primary conditions and labours of human life.

Thus, the ancient Greeks waited until the Pleiades were first seen, in May, to climb above the horizon before sunrise, in order to begin their season of navigation, and to them, therefore, the Pleiades were the "sailing" stars; and by many nations the cultivation of the soil was joyfully begun in November as soon as the Pleiades were for the last time seen to rise after sunset. The popular use of astronomical terms in defining time and season, by Chaucer and all mediæval writers, shows that in the Middle Ages the motions of the stars were not only the interest of special students, but were common and friendly concerns of the people in general. But in those days it was taken for granted that things were what they seem, and the stars were mysterious bodies closely linked with human destinies. They moved in space around the earth in wondrous harmonious rhythm, and could be trusted in the guidance of human concerns as no one then would have dreamed of trusting machinery or calendars.

But all the supposed motions of stars were destroyed at one blow by the incontrovertible establishment of the

Copernican theory, and our own world was made the sole cause of these profound circlings. Yet modern science is justifying the instincts of the old sages, and of all primitive peoples, by discovering new, real, and immeasurably vast motions in the stars themselves, individually and in concert. The existence of these motions is beyond doubt. Each star is moving through the heavens with a motion and determination of its own, perhaps shared with others which form with it a partial system among themselves; and it is at least possible that all the stars are united in some still vaster and more magnificent universal scheme of motion. But as to this latter nothing is actually known so far, and perhaps nothing may ever be known.

The proper motions of the stars are by no means easy of ascertainment. In the first place, observation is difficult, because the difference of position as seen by us in the heavens is so extremely minute, even though the actual distance traversed be billions of miles. It is usually recorded in angular measurement, for this is the only way in which we are able to measure movement across the line of sight; and even when we know the angular distance traversed by the star we can obtain no idea of the real distance which it traverses unless we also know the distance of the star from us.

Examples of Stars whose "Proper Motions" Can be Measured

Another difficulty arises from the proper motion of our own sun; for since we observe always from the standpoint of his system, whatever proper motion he may be subject to will appear, reversed, as a factor in the apparent motion of any star. The determination of the actual motions of the stars is therefore an exceedingly difficult and complex matter. It has to be extricated, if possible, from all these complicated details.

The angular proper motion, however, is the first thing to obtain, and this has been successfully measured in the case of a considerable number of stars. The star with the largest known angular motion is a small star in the Great Bear known as Groombridge 1830, from the number of its entry in the star-catalogue compiled by the astronomer Groombridge. This star is observed to move annually through a distance of seven seconds of arc. The actual distance signified by this depends, of course, on the star's distance from us; it has been computed to move at the rate of 232 miles per second. Two other stars have been discovered which move at an even swifter pace than this rapid flier of the Great Bear. One of these is a fifth-magnitude star in Cassiopeia, moving at the unimaginable rate of 305 miles a second; while Arcturus, the brilliant chief star in Boötes, moves at a rate of 375 miles a second. The angular motion of the Cassiopeia star is, however, only 3·25 seconds, and that of Arcturus only 2·3 seconds, but these two stars are at several times the distance from us of Groombridge 1830. It will be at once seen, therefore, that angular proper motions are only relative; they are qualified and determined by our distance from the star. They represent the movements of the stars, as it were diagrammatically, and as seen projected upon the background of the sky. Much additional knowledge is required in order to give absolute meaning to the diagrams.

Are Stars that Seem to Move Fastest Nearest to Us?

Keeping these limitations in mind, however, the consideration of the angular motions of those stars for which it has been ascertained is interesting, and opens up many speculative questions. It would be naturally expected that the observed large proper motions would belong almost invariably to the brightest stars, since these may be taken as being, on the whole, nearest to us; and, of course, the nearer the star, the greater an equal real motion will appear. But this is by no means found to be the case. Of eighty-three stars known to have a proper motion of as much as one second of arc in the year, or a greater proper motion than that, forty-five are invisible without the use of the telescope; that is to say, they fail to reach the sixth magnitude. Yet these eighty-three have the largest proper motions which have been discovered.

Position in Space No Criterion of the Velocities of Stars

The fact is a startling one. What does it imply? Are these faint stars really nearer to us than their feebleness would seem to suggest, or are their actual velocities extraordinarily enormous? In either case, under what law can we explain their movements? Is there some unknown force producing ever-increasing velocities in the stars as they recede further from us into space? Or is there, perhaps, an unrecognised special class of stars combining feeble luminosity with excessive swiftness?

Just as there is no uniformity in the real

brilliancy of stars, so that a bright star of the first magnitude may be actually further away than a dull, tenth-magnitude star, so there is no real uniformity in velocity; a sluggish movement does not necessarily imply greater distance, nor a rapid movement comparative nearness. In spite of this irregularity, however, it may be concluded that, *on the average*, swifter stars are nearer to the earth, and apparently stationary stars are enormously distant—just as, *on the average*, brilliant stars may be taken to be nearer to the earth than faint ones. It might therefore be justly expected that the apparent velocity of stars, taking whole classes together, would vary in regular ratio, according to magnitude. But so far this has not been found to be by any means the case.

The three stars with the largest angular motion are all telescopic objects—Groombridge 1830, mentioned above, which comes first with a motion of seven seconds annually, being below the sixth magnitude, and the two others being below the seventh and eighth magnitudes respectively. The annual proper motions of the two latter are between six and seven seconds. The only very swift stars of great brilliancy are Sirius, Alpha Centauri, Arcturus, and Procyon, the swiftest of these being Alpha Centauri, which has a motion of over three and a half seconds annually.

The Star that Appears to Move the Swiftest of All

This star is the nearest of all known to us, so that its distance has been measured, and its actual rate of progress ascertained. It moves at the rate of nearly fourteen and a half miles per second. The brilliant Centaur star is therefore by no means one of the really swiftest moving heavenly bodies, but its comparative proximity to us makes its movement appear great. Sirius also is comparatively near to us, and his actual motion has been reckoned at rather less than ten miles a second. Procyon moves at the rate of nearly fourteen miles a second. The large observed annual motion is in all three cases chiefly due to proximity. Arcturus, on the other hand, is probably at an enormous distance, so that its real motion may be taken to be of extreme swiftness, especially as it has also a considerable proper motion towards the earth, which is imperceptible to telescopic observation.

Not a single star of second magnitude is included in the list of the swiftest stars, and the average velocity of second-magnitude stars is excessively low. This fact, and the great swiftness of many very faint stars, are two of the anomalies of star movements.

There is another difficulty, suggested above in the case of Arcturus, which is being rapidly overcome by the application of the spectroscope to the study of the motions of stars. In order to be visible in the telescope, the movement of a star must be at right angles to the line of vision. Movement along the line of sight will not appear at all; and motions which are the resultant of a transverse movement, together with an approaching or receding movement, will be diminished to a degree proportionate to the amount which is thus rendered imperceptible.

The Record of Movement Directly Towards or From Us by the Spectroscope

Fortunately, the spectroscope is able to record these movements towards or from us, by means of the displacement of the spectral lines; and by the application of photography these records have been rendered so accurately decipherable that it has become possible to ascribe definite rates of movement along the line of sight to certain observed stars. For instance, it is known that Aldebaran is moving away from us at the rate of thirty miles a second, Capella at seventeen miles a second, Rigel at thirty-nine miles a second, Regulus and Castor at somewhere between twenty-five and fifty-eight miles a second. Other stars are known to be approaching us at similar speeds—the Pole Star at sixteen miles a second; Spica, the chief star of the Virgin, at fourteen miles a second; Procyon at seven miles a second; Pollux, Vega, and Arcturus at thirty-three, thirty-four, and forty-five miles a second respectively. Some of these stars have also well-known motions across the line of sight, so that their resultant velocity is much greater than at first appears. Pollux, for example, besides a motion of thirty-three miles a second towards us, has a transverse motion of nearly twenty-eight miles a second.

Stars which Clearly Move in Concert Across the Sky

Capella has a transverse motion of nearly twelve miles, in addition to a motion of seventeen miles in the line of sight. Procyon moves across the field of vision at a rate of nearly fourteen miles a second, besides approaching us at half that speed.

"Common proper motion" is taken to be an indubitable sign that the stars which take part in it are united in a system of some kind. Common proper motion does not mean mutual revolution, although

mutual revolution does very frequently connect individual members of a partial system. The relation of Venus and the earth is the relation of bodies sharing in a common proper motion within a partial system—in this case, the solar system. Several examples of a similar kind were referred to when we were considering multiple stars. A few others may be named here. Two small stars in the constellation Libra, both of the ninth magnitude, but at the wide distance apart of five minutes of arc, move swiftly across the sky in perfect concert, accomplishing an annual transit of nearly four seconds. Two others, separated by the even greater distance of twelve minutes of arc, move in a concerted progress of more than one second yearly. One of these is a fifth-magnitude star in Ophiuchus, the other a seventh-magnitude star in the Scorpion. It is probable that many other distant stars are actually connected with the known small systems, and pursue similar motions in far places of the heavens under the same influence, but about these we can so far only speculate.

The Difficult Problem of the Movements of the Whole Solar System Through Space

The problem which most intimately concerns us is the proper motion of our own sun among the stars. It is an essential principle of the universe that the sun himself must submit to the harmony of its movements; there is no more reason to believe that he is stationary than there is to believe that the earth is stationary. But the determination of the motion of our solar system through space is an extremely difficult problem, owing to the fact that we are in every way involved in this movement, and, with us, all our observations of external affairs. It is easy to see that it affects the apparent motions of all the stars in proportion to their distance and position with regard to the path of our journey; and if all the stars were motionless it would be a simple matter to determine the rate and direction of the movement of the solar system. But we know that the stars are all in motion, in all directions, and at greatly varying speeds. It has been discovered, however, that, underlying the apparent confusion of their movements, certain prevailing tendencies can be found which may safely be held to indicate the direction of the sun's progress. Herschel, in 1805, taking into account the movements of only a few brilliant stars, and tracing backwards the huge circular line of motion deduced from the fragmentary arc of their known movements, found for them a meeting-place in the constellation Hercules, and suggested that this would prove to be the point toward which the solar movement is at present directed. Further study of the question, based on a much wider and fuller consideration of stellar movements, tends to confirm this result, while correcting it and defining it more clearly. It is an intricate question of the greatest probabilities, and of reducing to a minimum the number of movements for which it is altogether unable to account.

How Far the Sun's Journey Through Space Has Been Mapped

The problem is to find a point in the sky such that the progress of our sun toward it will in itself account for the greatest number of stellar movements. Exhaustive attempts to fix this position correctly have been made by many astronomers since Herschell made his computation.

Perhaps the most elaborate and successful of these have been the labours of Struve, who fixed the path of the sun's progress as being at present directed towards a point in the constellation Hercules, in that part which forms the extended left arm of the hero. It is, however, almost certain that the sun's path is not a straight line, but an enormous curve, and that the same point will not always define the direction of his progress. But the curve is so immense, and the sun's movement comparatively so slow, that this direction will not change, to an extent capable of measurement by even the most accurate known methods, within a million years or longer.

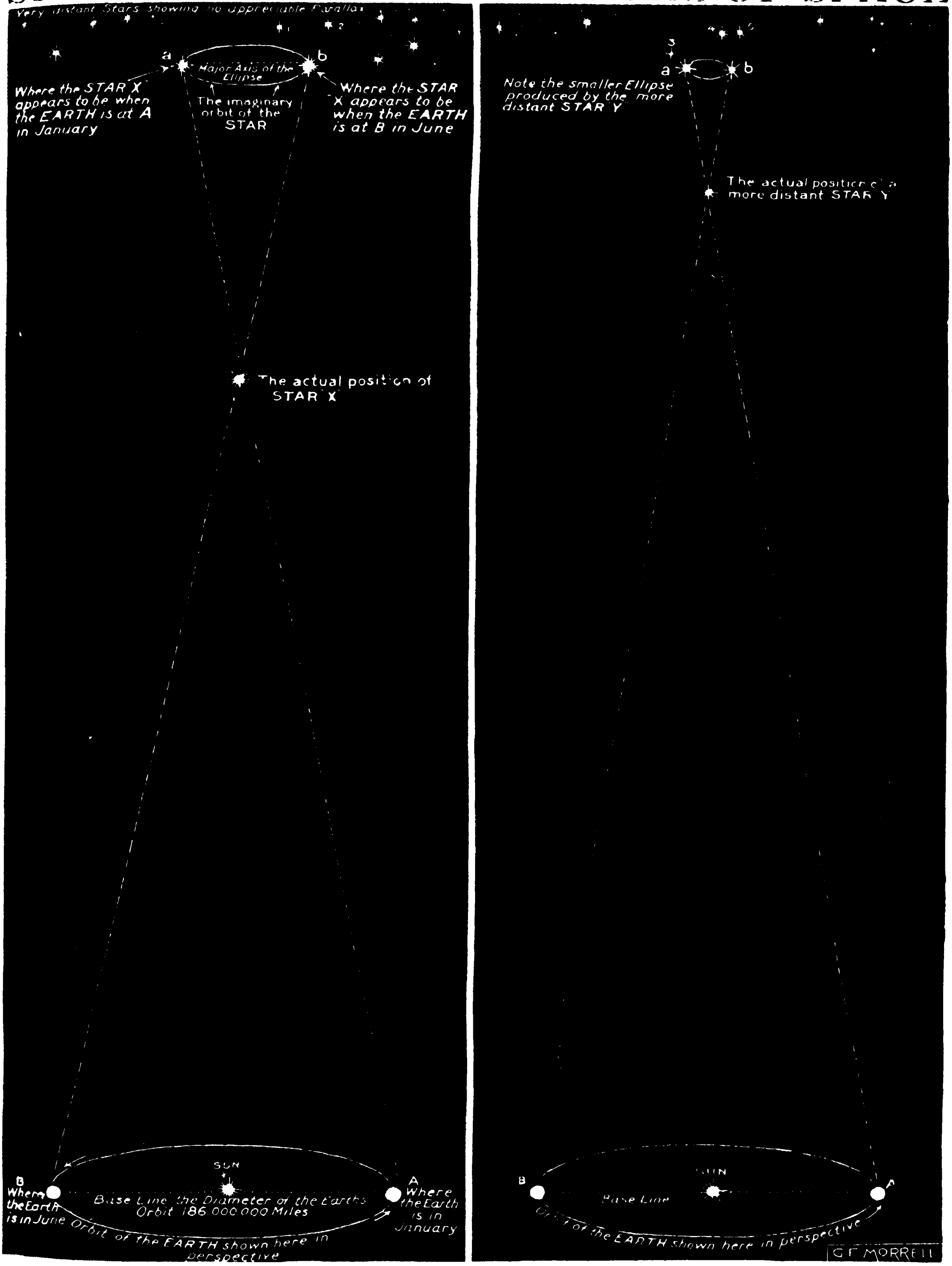
One other consideration must be noted. It is possible that this computed motion of the sun is not ultimate, but that, in common with other stars, he has also a drift along some vaster course. In travelling in a direction towards Hercules, our sun may do so as himself a member of some partial system; and in that case the discovered path would be a relatively small one pursued within the common movement of this system through space.

Is the Sun a Comparatively Slow or Fast Moving Star?

Careful observations in minute detail of the stellar movements left unaffected by this known direction of the sun's journey may in time throw some light on this possibility.

Very intricate studies of the rate of the sun's progress have also been undertaken, but it is impossible to clear up this matter finally without reliable knowledge as to the real distances of the stars. Different

SPANNING THE VAST DEPTHS OF SPACE



A DIAGRAM EXPLAINING THE PRINCIPLE ON WHICH THE DISTANCES OF STARS ARE ASCERTAINED

parallax of a star is the major axis of the apparent annual orbit which it performs as seen from the earth. Every star has a ...lax, but only a few are measurable, most, owing to their great distance, being practically infinitesimal. For instance, in the left-... diagram the star X, when viewed from the earth in June, appears at b in relation to the more distant stars 1 and 2, which have ...tically no parallax, but in January it appears at a. The projection which the major axis of the apparent ellipse performed by the ... X bears to the diameter of the earth's orbit enables astronomers by mathematical calculation to find out the number of times this diameter the star is distant. **The right-hand diagram shows the smaller parallax resulting from the more distant star Y.**

attempts have resulted in widely varying estimates, from as little as five miles to as much as one hundred and fifty miles a second. In this problem, however, as in others, the spectroscope is proving a powerful ally, especially since photography has been brought in to minimise the certain errors which would otherwise attend the calculation of exceedingly delicate measurements of spectral displacements. Everything depends on the correct measurement of extremely slight shiftings, so that a more direct and more permanent record is required than can be obtained by the eye and hand of even the most skilful observer.

The Support Given by the Spectroscope to the Slow Movement of the Sun

By applying spectroscopic tests with modern instruments, first to stars directly in front of the sun in his path, and then to stars directly behind him, a computation may be made with strong probability that it will give something nearly approaching the actual rate of solar progress. When a sufficiently large number of stars in each direction has come under observation, the result will be open to very little doubt. The spectra of stars in front of us will show the influence of movements of approach, while those behind will show the influence of recessive motion. Half the mean difference between the two sets of results may be expected to give the rate of solar progress. The most authoritative estimate obtained in this way describes the solar system as proceeding through space with a velocity of fifteen miles a second.

The problem of determining our distance from the stars is almost as old as astronomical research itself. It is certainly one of the most elusive of all problems, and is one that very directly affects many others. Questions concerning the physical constitution and relations of the stars depend upon the determination of distances for their elucidation. Real physical qualities, such as actual light-power, actual size, density, and the like, would be ascertainable if we knew the real distances, and real motions could be deduced easily and with certainty from apparent movements.

The Enormous Difficulty of the Problem of Measuring Stellar Parallax

Indeed, the determination of distance is the one factor chiefly necessary to convert the relative or subjective knowledge acquired by observation into the absolute terms of its actual meaning to the body itself.

But the difficulties in the way of determining the distances of stars are enormous. There are no fixed points, no known landmarks, no criteria for comparison. The only possible means open to us is the measurement of stellar parallaxes. From the time of Copernicus, parallax has been the object of much careful investigation. Astronomers have spent an immense amount of time and labour in studying the apparent displacements of the stars due to the earth's orbital journey round the sun. This displacement is called the star's parallax. Of course, this study of stellar parallax became the most absorbing of astronomical interests when the Copernican theory was first launched, and it began to be believed that the earth moved in an orbit. For if parallactic displacements could be observed in the stars, the proofs of that theory would be still more complete. If, on the contrary, none could be observed, the Copernican theory would involve a distance between us and even the nearest stars which was in those days utterly incredible. In the end, both of these facts have been established. Stellar parallax, though always exceedingly small, has been observed and measured in numerous cases. On the other hand, large numbers of stars have been carefully and unremittingly observed without betraying any signs whatever of such displacements.

The Calculations that Fix the Distance of the Nearest Star

Parallax is an effect of perspective. For example, if a penny be held out at arm's length and one eye is closed, so that the penny is seen projected upon, say, the window, in some position which can be definitely noted—for instance, at the meeting of two bars of the frame; if then the closed eye be opened and the other shut, the penny will be seen in a different position. If, while the penny remains fixed, the point of vision be moved in the form of the earth's orbit, the coin will be seen to perform a parallactic orbit upon the window. If the coin be held nearer to the eye, the orbit which it thus traces will be larger. This is the basal principle of stellar parallax. The parallax of any star is the angle subtended, at the distance of the star, by the mean distance between the earth and the sun. In other words, it is half the angular distance between the two positions of the star as seen, for example, in January and July. This angle being known, we are able to estimate, though only approximately, the distance of the star. For, the distance between earth and sun being ninety-three millions of miles, the actual distance at which this line of ninety-three millions of

miles is subtended by the given angle is easily discovered. In the case of an angle of one second, the distance of the star will be 206,265 times 93,000,000 miles. The nearest of all known stars, however, Alpha Centauri, gives a parallax of only three-quarters of a second, from which its distance is calculated to be about four and one-third light-years. The star with the second largest known parallax is a telescopic body in the constellation of the Great Bear, its parallax being half a second, which implies a distance from us which it would take six years and a half for light to travel.

No Approximately Known Distances of Some of the Great Stars

Thus the two nearest stars are found to present as great a contrast as possible, the first being one of the three supreme stars of the heavens, and the second an insignificant object which is not visible at all except with the assistance of a telescope. How did this unlikely star come to be chosen for parallactic observations? Astronomers had judged that it might be a near neighbour, in spite of its lack of brightness, as soon as they observed its large proper motion, which naturally suggests proximity. It moves through a distance of four and three-quarter seconds of arc every year, a proper motion which is exceeded, so far as we know, by only four stars. Indeed, a large proper motion has proved, on the whole, a safer guide than brilliancy in indicating stars likely to show a measurable parallax. About one half of the stars with sensible parallaxes are among the swiftest stars—that is to say, those with an angular motion of one second and upwards in a year. Among first-magnitude stars, parallaxes have been obtained for the following: Sirius, which is at a distance which light would travel in eight years; Procyon, at a distance of over twelve years; Altair, at sixteen light-years; Aldebaran, at twenty-eight light-years; Capella, Pollux, and Vega, at distances of thirty, forty-eight, and ninety-six light-years respectively.

The Use of Photography in Showing the Motion of the Stars

Accurate measurements of parallaxes are extraordinarily difficult to obtain. The whole amount, even in the nearest stars, is so minute that it is utterly impossible to secure any reliable results from comparisons of periodical positions of the star according to its absolute position in the sky —as measured, so to speak, by its latitude and longitude in the hollow sphere of the heavens. Such positions can never be defined with the extreme degree of accuracy which would be necessary for the purpose. The method adopted by most modern parallax-searchers is the use of comparison stars. The angle between the star under observation and some other star presumed to be considerably more distant is measured at regular intervals, and the results are compared. Periodic variations may safely be put down to parallax, especially if, as is now always done, several comparison stars are chosen, and the parallax is arrived at by combining the results. Photography has made this method easier, more certain, and applicable on a wider scale. The position of the star can be tested in relation to a large number of stars—as many, indeed, as are found on the plate in a suitable position; for only those stars are suitable which lie more or less in the directions towards which the major axis of the parallactic orbit points.

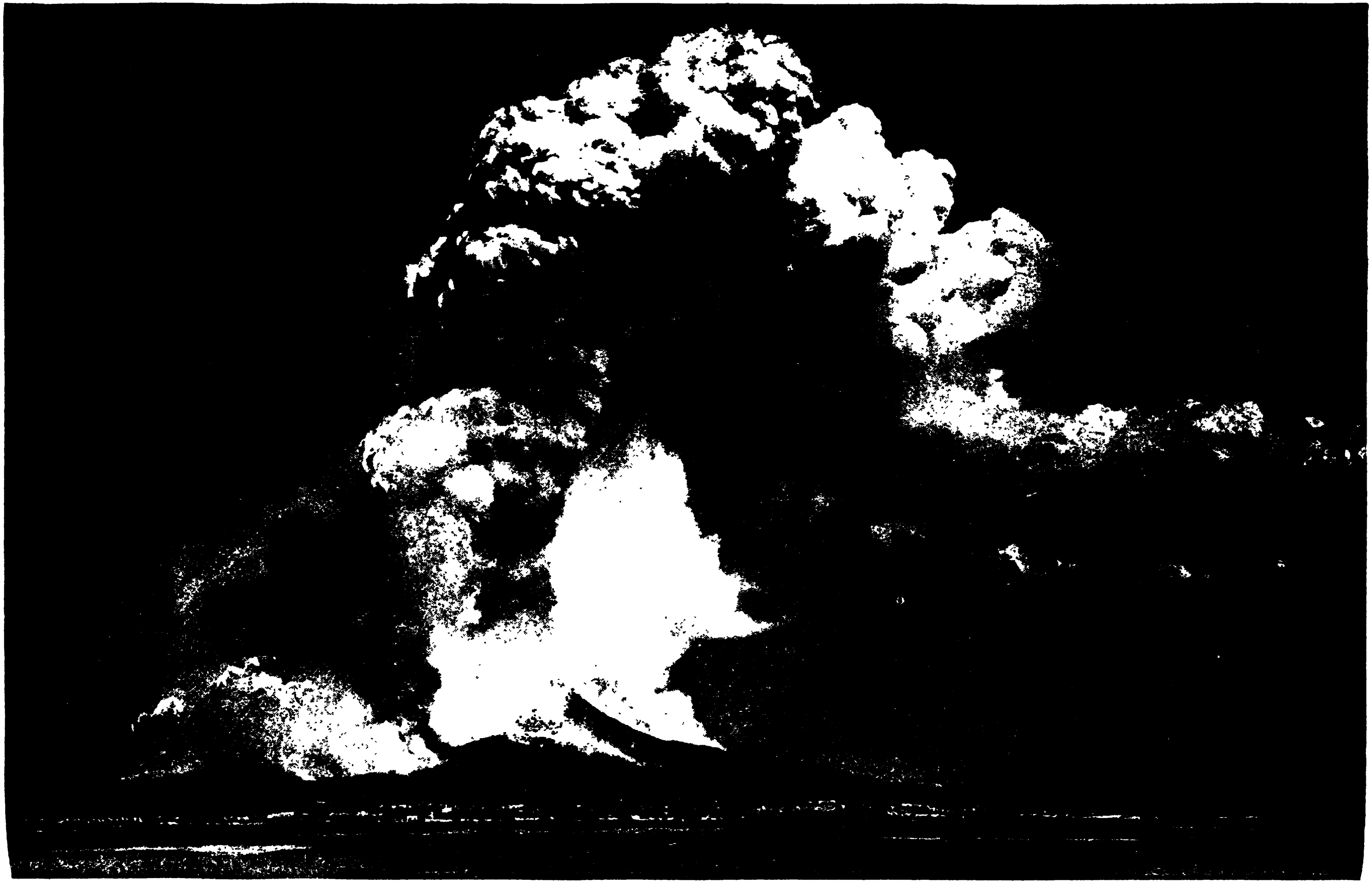
Of course, there is always the chance of error arising from parallactic displacements in the star which has been chosen for comparison, especially if this star be nearer to the earth than was imagined. Hence the great value of a permanent record providing many comparison stars and thus minimising the likelihood of error.

The Unimaginable Distance of the Stars Greater than was First Supposed

It is clear, however, that the results of this method can never be more than relative; and on this account they may make out the star's distance to be greater than it actually is, though the real distance of the star cannot be greater than its calculated distance. Thus, parallaxes carefully measured by means of comparative stars serve to fix definitely an upward limit to distance; and as the measurements are extended on a wider and wider scale they may eventually be relied upon to give very nearly accurate real results.

One thing at least the study of parallaxes has made clear. The stars are all at enormously greater distances from us than was ever imagined before. Our sun, with his system, is but as a speck in the ocean of space surrounding him. Unimaginable distances separate him even from his nearest neighbours. United to the most remote of them, and to all their invisible hosts, by relationships no less undeniable because to us barely conceivable—sharing, perhaps, with all, in some mighty comprehensive scheme of motion too vast even for the imagination to suggest its range, he yet rolls on in apparent isolation, so immense is the void which surrounds him on every side.

THE VIOLENCE OF VESUVIUS: A RAGING STORM OF FIRE FROM THE DEPTHS OF THE EARTH



SUCH A SIGHT AS THIS IT WAS THAT POMPEII LOOKED UPON; SUCH A SIGHT IT IS THAT EVEN NOW IS SOMETIMES SEEN ACROSS THE BAY OF NAPLES

GEYSERS AND VOLCANOES

The Various Forms Through Which the Earth's Internal Heat Bursts Forth

WAS OLD OCEAN MADE BY VOLCANO STEAM?

In the heart of the American Rocky Mountains, in the north-western corner of Wyoming, and including strips of the States of Montano and Idaho, is the wonderland of natural phenomena known, and now permanently preserved, as the Yellowstone Park.

The special and characteristic wonder of the Yellowstone Park are the geysers and thermal springs. There are over 100 geysers, and over 3000 thermal springs. The geysers are arranged in groups known as Basins. Thus we have the Upper, Midway, Firehole, and Norris Basins. The Upper Geyser Basin is the oldest. It contains nearly half of the geysers, including the Old Faithful, the Grand, and the Giantess. The Midway Basin contains a great geyser known as the Excelsior. The Firehole Basin contains weird cauldrons of boiling clay, known as "paint-pots," which when active throw up little puffs of blue clay. It also contains two great geysers, the Fountain and the Great Fountain. The Norris Basin is young, active, and in a very explosive condition, full of rifts and steam-jets.

The Excelsior Geyser is one of the most violent, but it has long periods of dormancy. When in action, it throws a column of water nearly 300 ft. in the air, and at intervals jerks part of the column even higher. Its eruptions occur about every seventy-five minutes, and are occasionally violent enough to toss rocks into the air. Even in non-eruptive periods it pours out 4000 gallons of water per minute. The Giant Geyser has also great power; it is able to fling a column of water, five feet in diameter, 200 feet high, and hold it in the air at that height for more than an hour.

The most regular of all the geysers is Old Faithful, which is almost clock-like in its regularity, and has spouted a slender column of water 125 feet high at intervals of sixty-five minutes for the last thirty years. The Miniature Geyser, the smallest on record, works industriously, but can spout its water only a foot high. A fine description of the spouting of the Castle Geyser is given by Lord Dunraven in his highly interesting travel book "The Great Divide."

"Far down in his bowels a fearful commotion was going on; we could hear a great noise—a rumbling as of thousands of tons of stones rolling round and round, piling up in heaps, and rattling down again, mingled with the lashing of the water against the sides as it surged up the funnel, and fell again in spray. Louder and louder grew the disturbance, till with a sudden qualm he would heave out a few tons of water, and obtain momentary relief. After a few premonitory heaves had warned us to remove to a little distance, the symptoms became rapidly worse; the row and the racket increased in intensity; the monster's throes became more and more violent: the earth trembled at his rage; and finally, with a mighty spasm, he hurled into the air a great column of water. I should say that this column reached, at its highest point of elevation, an altitude of 250 feet. The spray and steam were driven through it up to a much greater elevation, and then floated upwards as a dense cloud to any distance. The operation was not continuous, but consisted of strong, distinct pulsations, occurring at a maximum rate of seventy per minute, having a general tendency to increase gradually in vigour and rapidity of utterance until the greatest development of strength was attained, and then sinking again by degrees. But the increase and subsidence were not uniform or regular; the jets arose, getting stronger and stronger at every pulsation for ten or twelve strokes, until the effort would culminate in three impulses of unusual power. . . . The volume of water ejected must have been

prodigious; the spray descended in heavy rain over a large area, and torrents of hot water, six or eight inches deep, poured down the sloping platform."

Lord Dunraven also gives a striking picture of the trail by the side of the Firehole River. "Its banks and beds entirely composed of hot-spring deposit, are honeycombed, split up, and scooped out all over by geysers, springs, and pools, simmering, murmuring, gurgling, grumbling, spitting, snarling, steaming, hissing, exploding, boiling, and roaring—in short, making every sort of extraordinary noise. Some grumbled quietly along, as if enjoying themselves pretty well, breaking out occasionally into a sort of gurgling, explosive laughter. Others, often being quiet for a long time, got into a violent rage, spat or snarled, or hissed like angry geese."

The hot water ejected by geysers is always beautifully clear, but still it is highly charged with mineral matter, and round the orifices of the geysers there are incrustations of such matter that often assume beautiful or fantastic forms and colours. Thus, the Castle Geyser has made a beautiful white cone for itself, and the Great Fountain Geyser has formed a broad, circular pedestal about two feet high. The tints assumed by the mineral deposits are produced, as is now known, by algæ, which grow luxuriantly in the hot water.

AN ERUPTION OF THE OLD FAITHFUL GEYSER, YELLOWSTONE PARK

The amount of hot water which may be discharged by geysers is very large. The Excelsior Spring, even in its most dormant condition, discharges more than 250,000 gallons an hour into the Firehole River; and Old Faithful discharges about three times as much.

Though the geysers of Yellowstone Park are the most numerous and the most famous in the world, there are other districts where geysers are found. They were found, indeed, first of all, in Iceland, where the Great and Little Geysers and the Strokhr have long been known. Iceland is itself one of the wonders of the world—weird, grotesque, and sinister—a wonder of desolation. It is a land of fire and ice, of glacier and geyser, of lava and slush, of avalanche and volcano. Here "Nature breeds all monstrous, all prodigious things." It has no purple moors, no green fields, nothing but "raw-white and dull-black hues, like gulls' feathers strewed upon a roof of tarred shingles." An Iceland parson described his native land as "nothing but bogs, rocks, precipices; precipices, rocks, and bogs; ice, snow, lava; lava, snow, ice; rivers and torrents, torrents and rivers."

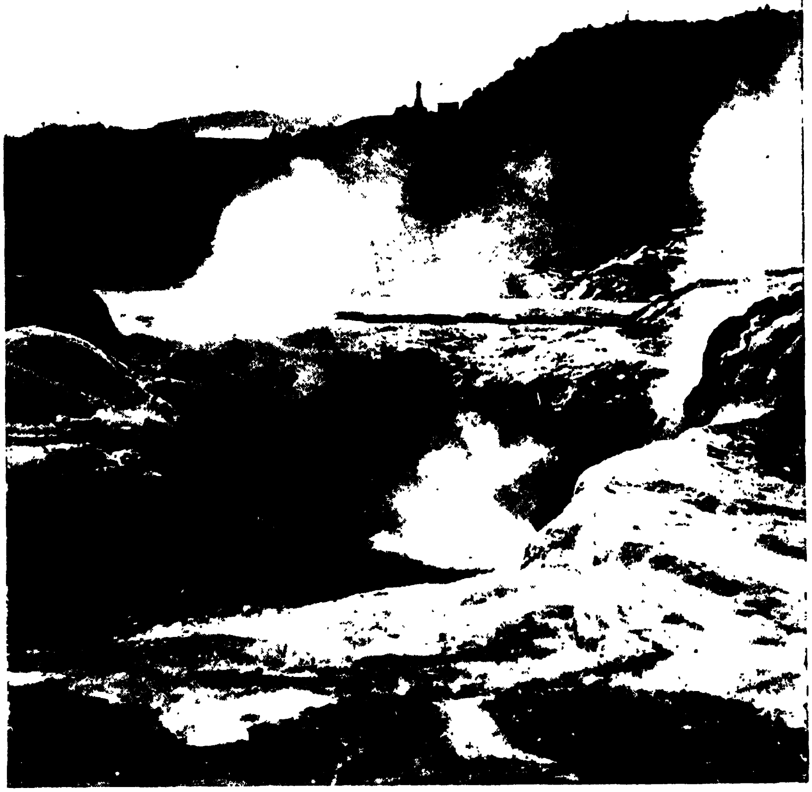
From the top of Odahahraun, a lava field extending over 1500 square miles, the

surface of the earth resembles a gigantic, stiffened corpse, petrified, black as the night. Altogether, no less than 5000 square miles of the island are black with lava, and 5550 square miles are white with snow. Rising from this black-and-white desert are great volcanoes, such as Hekla (5110 feet). Most of the volcanoes are quiescent now, but Dyngjufjöll, whose crater is twenty-five square miles in extent, and 3000 feet deep, was in eruption in 1875, and covered about 2000 square miles with its ashes.

In such an inchoate volcanic district it is not strange to find geysers; they are only one of many signs of volcanic activity. But the Icelandic geysers nowadays, whatever they may have been in former times, do not compare with the geysers of Yellowstone Park.

The Great Geyser has built a mound of silicious material for itself about 40 feet high, and from the saucer-like basin on its top a tube 10 feet in diameter descends about 74 feet. In its prime, it used to eject water to the height of 150 feet, but now the average height of its jet is only 70 or 80 feet. The sound of the geyser in eruption has been compared to the roar of an angry sea intermingled with the regularly recurring sounds of minute-guns.

The Strokhr has no regular basin, and consists of a funnel-shaped tube, narrowing from a diameter of 9 feet at the surface to 10 inches at 27 feet down. It can usually be made to erupt by throwing turf or stones into its tube, and, by regulating the amount of stone and turf thrown in, the time of eruption may be arranged. Taking advantage of this fact, Commander Forbes was able to cook dinner for himself and his friends in the geyser. He first threw in sufficient turf to ensure an eruption in forty minutes; then, packing a breast of mutton in the body of a shirt, and a ptarmigan in each sleeve, he threw shirt and its contents into the geyser. In due time he beheld his shirt in mid-air, and, recovering it, found that "the mutton was done to a turn." The Strokhr can spout higher than the Great Geyser, but frequently only spouts to 30 or 40 feet



THE BOILING POOL OF POHUTU GEYSER, NEW ZEALAND

A third great geyser wonderland is found in the North Island of New Zealand, in the volcanic country round Lakes Taupo and Rotorua. Here we find the greatest geyser in the world. It is situated in one of the craters formed by the great volcanic eruption of 1886, and has a tube 80 feet deep, situated in the middle of a hot lake. This tremendous geyser has not the beauty of the Yellowstone Park geysers, since the column of water it flings is muddy and

inky-black, but it surpasses the Yellowstone Park geysers in height, since it often hurls its water to a height of 500 feet, and on one occasion reached the record height of 1500 feet. At times it is dormant for weeks, and at other times it is active for weeks. Near Rotorua there are a number of geysers, but only the smaller ones are now active, and the Wairoa Geyser, which used to spout spontaneously to a height of 200 feet, will only spout when fed with bars of soap.

Before the great eruption of 1886 two geyser lakes by their overflow had produced these marvellous silicious encrustations known as the White and Pink Terraces. At the eruption these were destroyed. The White Terrace had about forty terraces, and rose to a height of 150 feet, and the Pink Terrace had about fifty terraces, and rose to a still greater height. Many a pen tried in vain to describe their exquisite beauty.

Before leaving the subject of geysers, let us look for a moment at the manner of their action. The motive power which raises the water is certainly heat forming steam; but how is it applied, and how does it act in this intermittent fashion?

THE WHITE TERRACES WHICH FORMED ONE OF THE BEAUTIES OF NEW ZEALAND

Sir George Mackenzie suggested that the hot water of the geyser was contained in an underground cavern. In this way cavern and tube together made a kettle-and-spout sort of arrangement. Into the cavern water continually percolated, and was heated by the heat of the hot rock around it till it boiled and generated steam. In time, the steam generated enough pressure to eject the water through the tube, even as water is ejected through the spout of a boiling kettle. It is not necessary to have a cavernous enlargement. If a bent tube, with two unequal arms, be taken, and if the short arm be sealed up, and the whole tube filled with water, then water will be suddenly ejected from the open, long arm if the water in the short arm be heated.

But Bunsen offered a still better explanation of the eruption of a geyser, founded on the fact that the boiling-point of water is lowered and raised as the pressure at the surface of the water is diminished or increased. Under ordinary atmospheric pressure at sea-level, water boils at 212 deg. Fahr. At the top of Mont Blanc, where the atmospheric pressure is less, it will boil at a much lower temperature; at the bottom of a deep mine, where the atmospheric pressure is greater, it will not boil till at a higher temperature. Now, in a deep pipe the water at the bottom is under the pressure of all the water above it, and so it requires a temperature of more than 212 deg. Fahr. to raise it to boiling-point, or, in other words, to convert it into steam, while water in the middle of the tube, being under less pressure, will boil at a rather lower temperature. But the hot water at the bottom of the tube rises through the middle layers, and so steadily increases their temperature; and so it comes about that the water in the middle layers boils first, and in time generates sufficient steam to eject some of the overlying water. The effect of this ejection is to diminish the pressure in the middle layers, which, in turn, lowers their boiling-point, and causes a sudden formation of steam, that ends in projecting the upper layers of water into the air with considerable violence. Then the cooled water drops back into the tube, and the heating process, with its resultant explosions, is repeated.

Bunsen's theory has gained more acceptance than Mackenzie's theory, simply because the machinery it requires is simpler, but, after all, a geyser is just as likely to be cavernous as to be a simple tube; in fact, it is more likely to have a cavernous and intricate structure than a simple one, for its subterranean beginnings were formed, no doubt, by explosions of steam in hot lava. Whatever the exact mechanism of the eruption may be, the motive power is heat—the heat of hot lava—and as this heat slowly radiates away, geysers must cease to spout. Indeed, in most parts of the world where they have been under observation for some time, they seem to be steadily losing force.

Volcanoes and geysers must be considered together, for they are undoubtedly akin.

Geysers are just a kind of volcano, and volcanoes are just a kind of geyser, but volcanoes are much more magnificent manifestations of force. They are, indeed, the most cataclysmic of all Nature's forces, with the one possible exception of earthquakes. All over the world volcanic craters are glowing and steaming, and rumbling and grumbling; and ever and anon, in paroxysms of violence, they devastate the land with clouds of fire and steam, with broadsides of boulders and rocks, with rivers of lava and hot mud. Vesuvius, Etna, Hekla, Stromboli, are familiar names of fiery fountains. To our forefathers they seemed the porches of the infernal regions.

THE RUINED CITY OF POMPEII AND THE VOLCANO OF VESUVIUS THAT DESTROYED IT

The word "volcano" is rather loosely used. It designates both such an active mountain as Stromboli, and such a dead mountain as the Puy-de-Dôme, in France. It is applied, indeed, to any hill which is in eruption, or which has been in eruption. Such hills are of all shapes and all sizes, but they are usually conical in shape, and often they are very lofty mountains. Orizaba and Popocatepetl, in Mexico; Cotopaxi and Aconcagua, in the Andes; Mount St. Elias, in North America; Kilimanjaro and Kenia, in Africa; Ararat and Damevend, in Asia, are all between 17,000 and 20,000 feet high. Many of their conical peaks are beautiful and picturesque. The Peak of Teneriffe (12,192 feet high), rising from the sea; Etna (10,570 feet), girdling with the Sicilian surf; Chimborazo (20,000 feet); and Fuji-san (12,400 feet), the sacred mountain of Japan, are all beautiful mountains, their beauty being increased in the two last cases by the plentiful snow on their summits.

The top of a volcano usually shows a more or less cup-shaped or basin-shaped depression, called the crater. The characteristic conical shape of a volcano is undoubtedly due to the manner in which the mountain is made. It is now established that the mountain is a compilation and accumulation of ejected materials. It is built up of lava, rocks, etc., ejected from a hole; and material thus ejected naturally assumes the shape of a cone with a funnel or pipe through its centre leading to a cup-shaped cavity at its summit. The exact shape of the cone depends on the viscosity of the lava and the cohesiveness of the material ejected—the more viscous the lava, and the more cohesive the material ejected, the steeper will the cone be. The volcanic cones in the island of Bourbon, which have been formed from very viscid lava, are about as steep as a thimble, while the volcanic cones in the Sandwich Islands, which have been formed from very fluid lava, have very gradual slopes, and may have a base with a diameter of seventy miles or so.

The composition of the cone of various volcanoes differs—some are composed entirely of cindery and slag-like fragments, others entirely of sheets of lava, and others of a mixture of both. The more massive volcanoes are usually built up out of alternate layers of lava-sheets and fragmentary material and volcanic dust; and crossing these layers in various directions there are numerous cracks filled with lava, which are known as "dykes." It may seem difficult to believe that volcanic mountains 15,000 or 20,000 feet high have been built up in this manner layer by layer; but it must not be

forgotten that the process of building may have been going on for a period of many thousands of years.

Mountains made in this way obviously are apt to be broken down as well as built up, and may change their shape considerably in the course of growth. Explosions or lava streams may tear away part of their summits, and in some cases their tops have been blown bodily off. Or new vents and new cones may be formed. During the last century Vesuvius changed its shape several times. In the times of the early Romans, its summit was a great, depressed plain nearly three miles across, where Spartacus the gladiator, with his followers, was besieged by a Roman army. After the great eruption of 79 A.D. it developed a huge crater, and within this crater a new cone with a smaller crater was formed. In 1822 a great eruption reduced its height by 400 feet, and produced a huge crater a mile in diameter and 1000 feet deep. In 1843, three small cones with craters had sprung up within this huge crater. The eruptions of 1872 and 1906 again changed its shape. And all active volcanoes are subject to such alterations in shape. The general effect of activity, however, is to increase the bulk and height of the mountain.

A Crater Twenty Miles Round on an Island in the Pacific

Though each volcano begins as a small cone, and is a cone to the end, yet almost all the great volcanoes develop subsidiary vents which give rise to subsidiary cones. Etna has, for instance, hundreds of these subsidiary or "parasitic" cones, which tend to destroy its primitive conical shape, and the volcanoes of Hawaii have thousands of these parasites. In most cases the vent by which matter is ejected is cup-shaped or basin-shaped, and is known as a "crater." The size of craters varies within very wide limits, and there would seem to be little or no connection between the size of the crater and the height of the volcano. The crater of Orizaba, a mountain over 18,000 feet high, is less than 1000 feet in diameter; the crater of Popocatepetl, a mountain 17,800 feet high, is only about twice as large; while the crater of Haleakla, a mountain 10,000 feet high, on one of the Hawaiian islands, has a crater 20 miles in circumference.

Nor does there seem to be much connection between the size of the crater and explosive potentialities, for Krakatoa and Pelée had craters of very moderate size. According to Réclus, the most astonishing and interesting crater in the world is the crater of Kilauea, in the island of Hawaii. It is three miles in its longest diameter, and seven miles in circumference, and is occupied by a lake of lava. The lake rises and falls, but it is usually about 600 to 900 feet below the rim of the crater, and covered with a crust which is constantly broken by the surging lava. "Jets of vapour whistle and hiss as they escape, darting out showers of burning cinders, and forming cones of ashes on the crust 60 to 100 feet in height, which are so many miniature volcanoes. In 1840 a great fissure 131 feet long opened in the side of the great cauldron, and vomited forth a stream of lava 37 miles long and 16 miles wide. On this occasion the great cauldron, 1476 feet deep, was entirely emptied, but in the course of time it filled again.

The Peaceful Lakes that Form in the Craters of Dormant Volcanoes

In the case of dead or dormant volcanoes the craters sometimes become filled with water, and form crater-lakes. The lake of Laach, in the Rhine Province; Lac Paven, in Auvergne, and Lakes Albano, Agnano, and Avernus are crater-lakes. The Crater Lake, in Oregon, has a circumference of 20 miles, is nearly 2000 feet deep in parts, and is surrounded by precipices 1500 to 3000 feet high. The crater-lake of Bagno, in Ischia, communicates with the sea, and thus forms a natural harbour.

The activity of volcanoes usually varies greatly from time to time. As a rule periods of partial or complete inactivity alternate with periods of paroxysmal violence. Until the eruption of 79 A.D. Vesuvius had been in repose for centuries. The eruption of Krakatoa took place after a slumber of two hundred years; and many volcanoes which seem now moribund or dead may have cataclysms in their wombs. Some volcanoes are constantly active.

A Volcano that Has Been Pouring Forth Lava for 2000 Years

Stromboli has been pouring forth lava for more than two thousand years. Izalco, which was born in 1770, has been in constant eruption ever since. As a rule, the great volcanic eruptions have been eruptions of volcanoes which have been dormant for many years; and the volcanoes that work constantly have been comparatively tame. Some volcanoes, such as the great volcano of Palma, in the Canaries, seem absolutely dead. Some have been dead so long that the great mountains they built in the days of their activity have been worn away

down almost to their very foundations. In the island of Mull, there is a group of hills, about 3000 feet high, the remains of a volcano which once had a height of 10,000 to 12,000 feet, and a circumference at its base of about 100 miles. The Red Mountains and Cuchullin Hills of Skye, which rise to a height of only 3000 feet, are the remains of a still larger volcano which was in full blast millions of years ago.

There are probably over 1000 volcanoes on the globe, and about 350 of these are known to be alive. The distribution of volcanoes is interesting. In a general way the volcanoes are distributed in a linear fashion, and are found along three main lines, which run north and south. One line runs north and south along the ridge which divides the Atlantic Ocean longitudinally into two basins. Along this ridge rise a number of volcanic islands, and on many of these are active volcanoes. The island of Jan Mayen has one active volcano; Iceland has at least thirteen, the Azores have six, the Canaries three, the West Coast of Africa eight, the West Indies six, and there are, moreover, three submarine volcanoes in the Atlantic Ocean. This line is about 1000 miles in length, and with its branches contains about fifty active volcanoes.

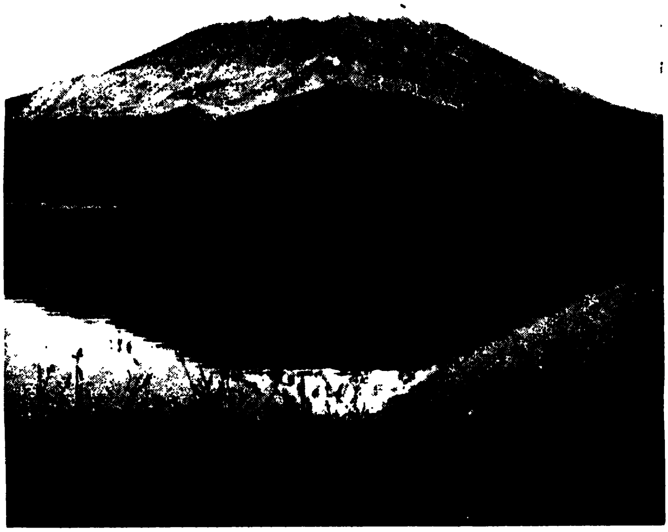
A second line of volcanoes starts near the Behring Straits, and runs all the way down the western coast of the American continent. This line is about 8000 miles in length, and contains about 100 active volcanoes. The third great line of volcanoes also starts at the Behring Straits, and runs down in the chain of islands between the Pacific and Indian Oceans. In the peninsula of Kamschatka there are twelve active volcanoes; in the Aleutian Islands, thirty-one; in Alaska, three; in the Kuriles, ten; in Japan (inland to the south), twenty-five; in islands off the south-east of Asia, fifty; in New Guinea, five; in New Zealand, three; in the Antarctic region, two. Altogether, this third great line of volcanoes stretches for 10,000 miles, and, with its branches, includes over 150 active vents.

A fourth line of volcanoes, but not nearly so important as the first three, includes the volcanoes of Mauritius, Bourbon, Rodriguez, and the eastern coast of Africa. These four lines include almost all the active volcanoes of the world; they all

MOUNT VESUVIUS BELCHING FORTH SMOKE, STEAM, AND LAVA

run in proximity to the sea, and the two largest bands form an almost complete circle round the Pacific Ocean. Another point to be noticed with regard to the distribution of volcanoes is that volcano bands usually run parallel with great mountain ranges—*e.g.*, parallel to the Rocky Mountains, the Andes, the Pyrenees, the Alps, the Balkans, the Caucasus, the Himalayas.

The proximity of volcanoes to the sea has often been explained on the theory that they are due to the ebullition of sea-water which has gained entrance to the hot rocks of the earth through fissures in the crust. But this theory is quite untenable, for there are volcanoes in inland deserts far from the sea, and the great volcanoes of the moon occur in the absence of water, and no doubt there were volcanic eruptions long before the sea was formed. It seems legitimate and necessary to hold that steam was a metallurgical product given off by primitive as it is by modern volcanoes, and that the oceans were formed by the condensation of the steam of volcanoes. The great oceans are ringed by volcanoes simply because they were made by volcanoes. The volcanoes are the fountains of the deep; and not only do they ring the oceans, but there are numerous submarine volcanoes (as the coral islands show) that spring from the bottom of the sea. And further, as deep-sea soundings show, deep-sea sediment is mainly volcanic dust. Moreover, it seems very probable, and in accordance with all we know about volcanoes, that the sea-beds were made by the subsidences of the earth's crust due to volcanic ejection of sub-crustal matter. Given a few hundred volcanoes vomiting forth matter like Krakatoa, and it is surely inevitable in the course of thousands of years that the circular area between them should subside. The Sunda Strait, between Sumatra and Java, is probably a subsidence area following a great volcanic explosion. If one eruption of one volcano can produce a subsidence of these dimensions, how large a subsidence might be produced by a few hundred volcanoes at work for a few thousand years! Even Mont Pelée, whose eruptive achievements have frequently been surpassed, vomited 40,000,000 cubic feet of solid matter every minute, or one and a half times the sediments discharged by the Mississippi in the course of a whole year. Tomboro ejected sufficient material to make three Mont Blancs, or to cover the whole of Germany two feet deep. Sumbawa, in 1815, discharged fully fifty cubic miles of material—enough, it is estimated, to make one hundred and eighty-five mountains like Vesuvius. And what an amount of honey-combing and excavation is represented by such giant mountains as Popocatepetl, Orizaba, and Cotopaxi!



THE SNOW-CAPPED VOLCANO OF FUJI-YAMA IN JAPAN

Moreover, the submarine volcanoes in the centre of the sea-bed-to-be would aid in the work of excavation. We know that hundreds of coral islands have been raised by volcanoes in the bed of the Pacific Ocean, and that, even as they rise, the ocean floor subsides. We know, too, that all the ancient Cambrian, Silurian, Devonian, Carboniferous, and Permian volcanoes were situated over subsiding areas, and that their lavas are now buried under thousands of feet of sedimentary deposits. These facts in themselves are very suggestive. Very suggestive, too, are the gentle undulations of the ocean floor, which shows such a contour as we should expect if it had been formed by subsidence—a contour very difficult to explain in any other way. Very suggestive, also, are the deep pits in the ocean—the Tuscarora Deep, the Deep

off Porto Rico, etc., in the neighbourhood of the most active volcanoes. Very suggestive also of some factor making continually for subsidence is the fact that at no time have the ocean deeps been raised as dry land. We hold, accordingly, that volcanic excavation and subsidence are quite competent to form the ocean beds, and many facts suggest that they were formed in this way.

It may be questioned whether the steam of volcanoes is competent to form all the water of the great seas. But steam is the chief product of volcanoes, and has been produced in prodigious quantities for millions of years. During one single eruption the discharge of water from Etna was computed at 28,296 cubic yards; and one of the little parasitic cones of Etna discharged 462,000,000 gallons of water in 100 days. The theory that volcanoes both made the ocean beds and filled them with water is quite in accordance with the facts of the case, and with the usual economical workings of Nature.

But there is still another argument in favour of this theory. It must be remembered that the seas are millions of years old, and that therefore, if they were the product of a certain definite amount of condensed steam, their water would long ago have sunk beyond recovery into continental soil, or entered into combination with other substances. But the seas have not dried up, and therefore there must have been a fountain to fill and refill their basins during these millenniums, and the fountain could be no other than the waters that are under the earth—waters that are made as by-products of the metallurgy of the molten crust, and given to the world by the steaming volcanoes.

Let us look for a moment at the phenomena of violent volcanic eruptions. Usually before a volcano erupts there are some premonitory symptoms, such as earthquakes, rumblings, sometimes disappearance of a lake, or rise and fall in its levels, or an increase in the activity of the volcano if the volcano be active. Then comes the actual paroxysm. Out of the crater rush enormous quantities of steam, mixed usually with small quantities of other gases, and carrying with them stones, rocks, ashes, lava, and various other ejecta. The rush of steam is accompanied by a prodigious roaring sound, and the ground shakes and trembles. The column of steam usually goes vertically upwards to a great height, and assumes the form of a pine-tree, to which it was compared by Pliny the younger. In many cases, jets of liquid lava go up with steam, and the friction of the steam against the crater walls creates electricity, so that peals of thunder are heard, and forked lightning flashes to and fro through the column. In many cases the column is laden with incandescent particles, and occasionally there are gases in it which are set on fire; and in all cases it is lit up by the glowing lava in the crater, so that it seems on fire. In the case of the worst eruptions the column is so thick and so black that it hides the sun, and makes

THE CRATER OF EL MISTI, A SEMI-ACTIVE VOLCANO NEAR AREQUIPA IN PERU

an impenetrable, pitch darkness. The condensation of the steam causes torrential rain, and muddy rivers flow down the sides of the volcano, and may bury cities, as Herculaneum was buried, at the base of the volcano.

The height to which the column of steam and contents rise may be tremendous. In 1779, Vesuvius is said to have thrown columns of lava and cinders and steam to the height of 10,000 feet; and on some occasions its column of vapour was estimated to reach 23,000 to 26,000 feet, while ashes from Krakatoa were calculated to reach a height of seventeen miles. The amount of lava and solid matter ejected varies. In some cases, as in the case of Mont Pelée, the main discharge is steam; in other cases there is a tremendous amount of lava, and in other cases a tremendous amount of cinders, ashes, or pulverised rock. In some ways lava is the most characteristic product of a volcanic eruption, but nevertheless some volcanic eruptions produce no lava. In the great eruption of Mont Pelée no lava was discharged—only prodigious quantities of sand and stones and incandescent dust.

A Stream of Lava that Travelled as Fast as an Express Train

As a rule, however, when the volcano has cleared its throat, lava begins to flow from the crater, or even to spout high into the air as a fountain of molten metal. Usually the lava pours over the edges of the crater, or through fissures in its sides, and when a crater is much fissured it seems to "sweat" lava from numerous pores. Flowing lava is at first white-hot, and steams as it flows. As it cools it grows first red and then black. The rate of flow is often at first very rapid, especially if the slopes down which it pours are steep. In 1805 a stream of lava from Vesuvius flowed about four miles in four minutes—that is to say, it went at about the rate of an express train. But of course the rate of flow varies with the viscidity of the lava, and with the slope of the ground down which it flows. When it reaches a steep cliff it pours tumultuously over it as a cataract, while on gentle slopes it may move very slowly. Also, as it cools it becomes more viscid, and runs with great difficulty.

The surface appearance of the cooled lava depends on its chemical nature, and on its viscidity when flowing. Viscous, sticky lavas break up, as they cool, into brown or black clinkers or slags, which grate together as the lava continues to flow, and often get piled up into mounds and he[illegible] More fluid lavas take on a twisted rop[illegible] like structure, which Professor Geikie like[illegible] to the scum of a sluggish river. The heat [illegible] lava is very great—in many cases mor[illegible] than 2000 degrees Fahr. It fuses eve[illegible] flint. It is a bad conductor of heat, an[illegible] cools very slowly, so that, when it [illegible] cool enough at the surface to be walk[illegible] upon, it may be red-hot below. Many re[illegible] markable instances can be given of th[illegible] extreme slowness with which lava cools. I[illegible] 1830, steam was still issuing from lav[illegible] which had flowed from Etna forty-thre[illegible] years previously.

The Vast Rocks that are Flung Far and Wide by an Active Volcano

Jorullo, in Mexico, discharged lava i[illegible] 1759; twenty-one years later a ciga[illegible] could be lighted at its fissures, and eighty[illegible] seven years later two columns of stea[illegible] still rose from it. This slow cooling [illegible] the lava obviously suggests that the cru[illegible] of the earth, though cool, may contai[illegible] molten matter a very short way down.

Besides lava, as we have said, volcano[illegible] discharge huge quantities of rocks, stone[illegible] cinders, and ashes. It is difficult to g[illegible] authentic measurements as to the size [illegible] the rocks and stones a volcano can hu[illegible] and the distance to which it can hu[illegible] them. During the eruption of 1779, Vesuvi[illegible] hurled cinders to more than twice th[illegible] height of Ben Nevis. In 1815, Timbo[illegible] covered the sea for miles with pumice-sto[illegible] more than a yard deep, so that ships coul[illegible] hardly force their way through it. Amon[illegible] the ashes which buried Pompeii are ston[illegible] eight pounds in weight. Antuca, in Chili [illegible] said to send stones flying to a distance [illegible] 36 miles. Cotopaxi is said to have flung [illegible] 200-ton block nine miles, and Asama, i[illegible] Japan, tosses about blocks of stone 40 t[illegible] 100 feet in diameter.

The Darkening of the Sky and Ruin of the Soil Wrought by Volcanic Dust

But even more astonishing than all th[illegible] is the distance the dust belched forth b[illegible] volcanoes may float, and the great propo[illegible] tion it often bears in the total amount [illegible] material ejected by the volcano. Whe[illegible] Coseguina blew to pieces, it is compute[illegible] that 6500 million cubic yards was cast t[illegible] the winds. The dust was carried at lea[illegible] 800 miles, and sprinkled an area of 1,500,[illegible] square miles. When Timboro erupted [illegible] 1815, dust fell on the island of Borne[illegible] 870 miles away, in such quantities tha[illegible] the inhabitants still date their years fro[illegible] "the great fall of the ashes." Similarly

after the great eruption of Skaptar Jökull, in 1783, ashes fell in such quantities in Caithness—600 miles away—as to destroy the crops, and that year is still spoken of by the inhabitants of Caithness as "the ashie" year. In 1877 the dust from an eruption of Cotopaxi plunged the city of Quito into pitch darkness. The dust from Krakatoa darkened the sky for 150 miles from the mountain, and fell in recognisable quantities 1000 miles away. These figures will give some idea of the prodigious pulverising capacity of a volcano.

The darkness caused by the dust is one of the most trying and terrible features of a volcanic eruption. To be shut into an impenetrable darkness, lit only by lightning flashes and the glow and glare of molten lava, must be an experience to try the stoutest heart. To escape from the night of terror made by the dust of Coseguina, in Nicaragua, men, women, and children fled in a body from the mountain, and it is recorded that animals, such as monkeys, serpents, birds, joined the fugitives, "as if they recognised in man a being endowed with intelligence superior to their own." But, strangely enough, this dust, which at first makes a blackness as of hell, is ultimately the cause of beautiful and gorgeous skies. Floating in high heaven, and sometimes making several circuits of the globe, the fine volcanic dust refracts and reflects individual colours of the sunlight, and produces surpassingly beautiful sunset and sunrise effects all over the world.

AN ERUPTION OF ASAMA YUMA, JAPAN

We have already mentioned the torrents of rain and mud that are often accompaniments of a volcanic eruption. Where there is dust, rain soon makes mud, and the deluges of water from the volcanic steam soon convert the volcanic dust into a sticky mud that overwhelms and buries all it meets. By such a flood of mud Herculaneum was buried during the eruption of Vesuvius in 79. The great eruption of Cotopaxi, in 1877, buried many mountain villages under a deposit of mud mixed with blocks of lava, ashes, pieces of wood, and lumps of ice. In some cases, the rivers of mud laid whole forests low.

A special class of volcanoes, the submarine volcanoes, must be given a word. Etna, Vesuvius, Stromboli, and many other volcanoes had their birth under the sea, and no one knows how many active volcanoes may be at work in the ocean depths. Often they throw up cinders and steam, and agitate the surface of the sea. Occasionally they betray their presence in a very sensational way. At times they elevate a new island into the air, and drag an old island down into the sea. St Michael, in the Azores, is a favourite place for these emergences and submergences, and on several occasions new islands have come and gone. The Mediterranean Sea, too, is accustomed to islands that bud, and then disappear again. In 1831, between Sicily and Africa, a new island made of lava and cinders suddenly appeared. It reached a height of 200 feet above water, and attained a circumference of three miles, but it melted away again, and in 1832 no signs of it could be seen. Between Sicily and Greece new islands are often thrown up, but as quickly as they come they go. Some islands, however, thrown up by submarine volcanoes do last. For instance, in Behring Sea, in 1795, a new island, which the Russians called Joanna Bogoslova, appeared, and it is still in existence. Not only so, but in 1883 a second new island, now known as

New Bogoslova, emerged as if with the intention of keeping it company.

Volcanoes are built up out of material ejected from the earth's crust, but it is not necessary that all ejected material should grow up into volcanoes. In some instances, in the case of what are known as fissure eruptions, lava flows out of a fissure in the earth's crust, and may cover a large area without the production of anything like a volcano cone. Some of these fissure eruptions have been on an enormous scale, and have covered enormous areas with lava.

The Vast Sea of Lava that Once Covered a Large Part of Britain

In Iceland such fissure eruptions have been common. In 1783 two streams of lava issued from a twenty-mile fissure, and flooded respectively forty and twenty-eight miles. Another stream of lava sixty miles long flowed from a fissure in prehistoric days; and the great lava-desert of Odahahraun, which covers an area of about 1700 square miles, is also a product of a fissure. In the north-east of Ireland, there is evidence of great lava leakage in Tertiary times. It has been said that altogether no less than 40,000 square miles in Britain were at one time under a sea of lava which in some places was 3000 feet deep. In Africa large tracts of Abyssinia are covered with fissure lava, and in India more than 200,000 acres show evidence of such a baptism. But in western North America the best examples of this fissure outflow are found. Here, an area greater than France and Great Britain has been flooded with fissure lava in some places deep enough to submerge Snowdon.

When we come to consider the causes of volcanic eruptions, we find ourselves largely in the region of conjecture. We have to discover both the source of the molten material and the mechanism of its ejection.

Theories that Have Been Brought Forward to Explain Eruptions of Volcanoes

The first ideas to occur to geologists were not over-wise. It was suggested that the heat might come from burning coal, or from contact between water and sodium and potassium. Possibly they might, but there is not the least reason in the world to suppose they do. Then it was supposed that, under the solid crust of the earth, between the solid crust and a solid core was a layer of molten material sufficient to supply any number of volcanoes. It was further supposed that as the crust cooled it contracted on the molten material, and squeezed some of the molten material out. It was calculated that a contraction of 1-25th of an inch would suffice to squeeze out 650,000 million cubic yards of lava—enough for many hundreds of eruptions.

But this theory cannot be maintained. In the first place, the crust is about 800 miles thick, and lava does not come from such depths; in the second place, we have no proof that there is this sub-crustal layer of lava; and in the third place the outflow of lava is usually periodic and paroxysmal. Mallet, accordingly, suggested an interesting modification of this theory. He found in the contraction of the earth's crust at once the source of heat and the cause of ejection The contraction of a cooling crust would certainly cause great pressure and great heat; the pressure and heat would be unequally distributed, and at parts would be so great that reservoirs of molten rock would be formed. To these reservoirs of molten rock water would gain access, would be intensely heated, and on any diminution of pressure would flash into steam, with explosive consequences. This theory would explain the superficial position of volcanoes and their linear relation to mountain chains, where, presumably, there has been very great pressure.

The Part Played by Steam in the Causes of a Volcanic Eruption

This theory of Mallet's is still widely held. Whatever the source of the molten matter, it is pretty certain that steam plays a considerable part in the explosive energy of an eruption, even though there may be some doubt as to how the water obtains access to the molten matter, and as to what happens to it there.

Professor Arrhenius has pointed out that, granted the access of water, it is possible that the explosion may be partly of a chemical character. At a temperature of 1000 deg. Centigrade or 2000 deg. Centigrade water will enter into chemical combination with the molten metal, and displace silicic acid, causing the molten mass to swell and to rise in the volcanic chimney. As the molten metal rises, it cools, and the water is again expelled from the metals, and passes with violence into steam. But there seems no necessity to postulate water, for all melted rocks absorb huge quantities of gases, and give them off again on cooling with eruptive violence. Indeed, it seems quite likely that gases and steams may be ordinary by-products of rock formation and, in this case, we have an explosive force always ready to hand. Professor Ischermak has calculated that if 190 cubic kilometres

THE INTERIOR OF THE CRATER OF VESUVIUS DURING A PERIOD OF INACTIVITY

LAVA FROM VESUVIUS POURING IRRESISTIBLY OVER A MODERN VILLAGE

of iron solidify annually, and give off fifty times its volume of gases, it would suffice to maintain 20,000 active volcanoes.

A still further source of gases may be found in metallic carbides which, on contact with water, give off liquid and gaseous hydrocarbons and carbonic acid gas. On the whole, though the source of the localised heat has yet to be discovered, though there may be a difference of opinion as to the precise *modus operandi*, there is a consensus of opinion that the ebullition of a volcano or a geyser is of very much the same nature as the boiling over of a pot of porridge, or the squirting out of aerated water from a siphon is very much a matter of ebullition of gas.

When one considers all the tremendous reservoirs of heat stored in volcanoes and hot springs, the question naturally suggests itself—cannot this heat be utilised to do work? Why should we not use the mighty furnaces of Nature to turn turbines and work mills? Why should not Vulcan and Vesuvius be sentenced to penal servitude for their sins? Or, if we are afraid of these monsters, why should we not use the more gentle heat which, in many parts of the world, is just below the surface of the earth? Three pounds of boiling water represents about one horse-power, and "as a source of energy a very hot spring is equal to a very large waterfall."

But the heat of the crust of the earth, representing enormous energy, remains, for the present, to all intents and purposes, unharnessed and unutilised.

A LAKE IN THE CRATER OF AN EXTINCT VOLCANO IN GLACIER PARK, OREGON

MEDICINE OF TOMORROW

Revolutionary Changes that are Proceeding Alike in Surgery and in Medicine

RIVALRY OF CHEMISTRY AND THE KNIFE

For once, here is a case where we may prophesy, because we know. The future developments of medicine are already crowding upon the present, and none can doubt them. The sooner we are prepared to understand them, the sooner they will be realised. First, let us observe the paradoxical fate of Listerism, the great surgical method which we discussed in a former chapter. Here is the most beneficent achievement of the human mind coming to its maturity within a generation, when all preceding generations had gone without it; and now it is about to undergo the most extraordinary decline in its scope, after threatening to supersede all other forms of treatment.

Hitherto, in its brief and brilliant career, Listerism has advanced from one part of the body to another, and from one type of malady to another, until mere medicine, the future of which we propose to discuss, threatened to disappear altogether. The surgeon has advanced from the limbs to the trunk, from the abdomen to the cranium, and from the cranium even to the heart, until it seemed as if the knife were to be Life's best champion. Even where organs had degenerated, like the kidney in Bright's disease, and were tightly strangled in a coat made thick and rigid by long inflammation, the surgeon has tried to strip off the strait-jacket of the gland, and so to restore its blood-supply and its health.

But here we must proclaim a new stage in the history of surgery, a stage in which the very discoveries that made it possible will supersede it in large degree. Let us take, for instance, what is usually called "surgical tuberculosis." A child has a "white swelling" of the knee-joint, which yields to no remedies. Later, he suffers from starting-pains at night, and serious lameness. After injections of iodoform and other remedies have been tried, Listerism is called in. The surgeon exposes the knee-joint, and removes it bodily. He apposes the thigh-bone and the shin-bone, each with a perfectly healthy raw surface, the disease having been completely removed, and they soon unite, giving the patient a single shaft of healthy bone from hip to ankle. This is a remarkable and triumphant achievement, which has saved scores of thousands of legs in the past two decades or so, and is evidently much to be preferred to the cleanest amputation.

But what of the two chapters in which we discussed the struggle for life between man and the tubercle bacillus? Clearly this is a case where we want something better than the best Listerism—or perhaps we want something which corresponds to that latest development of Listerism, which we call aseptic surgery. The principle of that method is to prevent microbes from ever reaching the tissues of our patient. Let us apply this principle to the care of our children's milk, and there will be no more tuberculous knees for Listerism to excise.

"Surgical tuberculosis" must be responsible for not less than twelve thousand deaths annually in Great Britain, to say nothing of the pain, the deformity, the inefficiency, and the expense which it causes. Listerism can do and does great things here; but the wards and out-patient departments of all our general hospitals are besieged by cases of the disease, and there are not competent surgeons enough in the civilised world to meet the whole of the need. Yet the reader who has studied the matter will not doubt that, within a decade at most, we shall take proper care of the milk-supply, and surgical tuberculosis will have joined leprosy and typhus in the limbo of the bad old days. There will be an end, then, both of surgery and medicine so far as this disease is concerned. Even the finest and

most efficient anti-tuberculosis serum, not yet invented, will be as superfluous as the Listerian knife.

The largest of all the fields of surgery will thus disappear altogether in a few years. It furnishes a type of the many microbic diseases against which Listerism fights, and which may be abolished altogether. Of another order is the case of rickets, to which we have referred previously, because of the great achievement of Listerism in relieving knock-knees. But rickets is an entirely unnecessary and inexcusable disease. It is not "congenital," but the post-natal consequence of post-natal malnutrition. It will disappear when instruction in the elements of infant and child feeding is given to all girls in our schools, even at the cost of inattention to the particular selection of fictions commonly miscalled history. Here the promise of the future is that there shall be no more need for either medicine or surgery. We should remember, also, that though the surgeon is apt to think of rickets as a disease of the bones, the pathologist knows that this is a disease of all the tissues, involving malnutrition of the brain as well as of the skeleton, so that no surgery can ever remove all its consequences. We should do better to give children enough good bread-and-milk, and say good-bye to all kinds of saws and syrups.

Expected Cure of the Microbic Diseases by the Use of Anti-Toxins

The present surgical requirements of such a disease as syphilis cannot much longer be in demand. Shortly we shall see how medicine will come back to its own again in this field, using weapons infinitely subtler than the cleanest knife. As for the ally of syphilis, which is responsible for such incessant surgical need among innocent and ignorant women, it also must go to its own place before long. Only the stupidity, prudery, and faithlessness of public opinion stand between Science and the abolition of the disease which is responsible for one half, at least, of all the cases where abdominal surgery is required by women. We can close most of the special hospitals for women, and say farewell to so much Listerian surgery, when we please.

In men the commonest need for abdominal surgery is due to appendicitis. Many thousands of operations yearly, in this country alone, are required by this disease. But our standard keeps on rising.

A decade or two ago it seemed an almost supreme triumph of the human genius that the surgeon should be able to cure appendicitis and avert peritonitis by means of a daring operation which involved opening the body of a living man. Such hosts of people, now alive and well, owe their lives to this procedure that we can scarcely decry it. But we begin to see that the knife is much too clumsy for us to rest content.

We must ascertain the dietetic errors upon which, beyond much doubt, the occurrence of appendicitis will be found to depend, because they favour the growth of the microbes which cause the disease; and even sooner than that we may be provided with something comparable to the diphtheria anti-toxin, which will control the inflammation in its earliest stages, and render the use of the knife superfluous.

The Fading Belief in the Appendix as an "Ancestral Relic"

Here a special note must be made regarding the appendix. The accepted view of ten years ago was that this is an organ useless in man, a kind of "ancestral relic" which is interesting to the evolutionist because it speaks of past stages in the history of our species, and illustrates certain theories of organic evolution. The surgeon might argue that his knife simply hastened the natural evolutionary process by which the appendix is becoming decadent in our species. Enthusiastic surgeons have argued that the appendix should be removed from every infant within the first fortnight, in order to prevent appendicitis, and hasten the slow processes of organic evolution. In his recent Presidential Address to the British Association, Professor Schäfer quoted the appendix as one of the organs which remain in our bodies though they are useless, and of which the surgeon may rid us today, though our posterity will be rid of them by means of the progress of organic evolution.

The Evidence that the Appendix is Not a Decadent Organ

Comparative anatomy gives us quite another view. The appendix is not a decadent organ at all. The lower mammals do not possess it. Only when we reach the anthropoid apes and ourselves do we find an appendix appearing. It is not the shrivelled remains of some digestive organ which we find in full size in the horse or the cow or the reptile. It is a comparatively recent addition to the alimentary apparatus. The anthropoid apes possess this organ, and in them it is doubtless useful. It may be useful in

ourselves, for all we know; the fact that we can do without it may merely mean, as in many other cases, that some other organ assumes a compensatory function in place of it. Professor Arthur Keith, our greatest authority, says in his recent admirable book on "The Human Body" that, "So far we have never known of appendicitis occurring in anthropoids in a state of Nature, but they do become liable to this disease when kept in captivity and fed on a human diet." A little later he speaks of the order of mammals to which we belong as having "acquired an appendix."

How Listerism and the Knife Hold the Field for the Moment

Thus we see that exact knowledge entirely reverses the view accepted by Professor Schäfer and popularly quoted. As in some other cases, we have been inclined to blame Nature because we were abusing her and she resented it. In the light of recent knowledge we can no longer encourage the surgeon, emboldened by the Listerian impunity of his most daring procedures, to remove whatever parts of the body we have not yet succeeded in discovering a use for. It would be better to revise our diet, perhaps, and be content to possess a functional appendix, doing some useful work for us, no doubt. We may note that the appendix certainly contains the tissue which produces white blood-cells, so that it helps to provide us with those invaluable defenders, even if it does nothing else.

It may now be taken as practically certain that cancer is not a microbic disease. The malignant tumours, including cancer and sarcoma, still defy elucidation, as do their innocent allies, the fatty and muscular and other "benign" growths. For the present, Listerism holds the field, and does great service, no doubt. Indeed, it is the duty of all who write for the public eye to insist that Listerism should be had recourse to at the earliest possible moment in cases of malignant disease, whatever else be done.

The Study of the Chemistry of the Body as the Pathway of Hope Against Cancer

But the prospect of something far better is extremely hopeful, and at any moment the discovery may be made which will for ever banish the knife from this field. The public opinion that there is something peculiarly hopeless about the problems of cancer is not shared by experts. On the contrary, so much definite progress has been made within the past decade that the time can scarcely be far distant when the knife will be rendered superfluous by the introduction of chemical substances in the presence of which malignant cells cannot live. There are those who believe that such substances can already be named.

The key to the solution of this problem, and to the replacement of surgery by a better medicine in the treatment of malignant disease, is to be found in that great department of the study of life which is called bio-chemistry, and of which the biology of the future will more and more consist. The best hope lies in the very fact that cancer is now being studied by biologists, as part of the problem which living tissues offer for their solution. We must study the chemistry of those human or animal patients in whom there occurs spontaneous recovery from malignant growths. Hitherto, such cases have been too much regarded as mere curiosities, which did not demand the help of the surgeon, and were therefore of no further interest to him. On the contrary, they contain the hidden solution of the problem, and that solution is being found by the men, not surgeons, but students of the living cell, who are engaged upon that task.

Recent Discoveries Suggesting that We are on the Track of Curative Knowledge

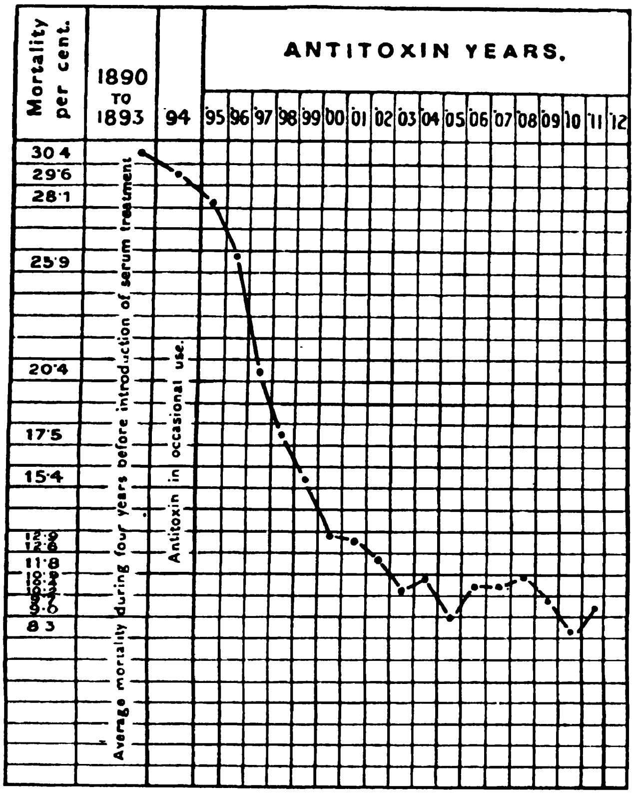
For instance, three cytologists, or students of the cell, made a remarkable discovery a few years ago, which has guided subsequent research. They found that the cells of a cancer had only half the number of chromosomes in their nuclei that is characteristic of the species in whom the cancer is occurring. In other words, as we may recall from our study of the genetic process, the malignant cell has the same number of chromosomes as a germ-cell, formed by the process of gametogenesis. Another student, Dr. John Beard, of Edinburgh, has shown that this feature of the malignant cell corresponds to the facts of the alternate or asexual generation which alternates with the sexual generation in many animals and plants, and he has suggested a line of treatment, on this view, which may yet prove to be our salvation.

Another student, Dr. Ross, a brother of Sir Ronald Ross, has studied the subject from the standpoint of cytology, and has found some of the conditions under which abnormal division and multiplication of cells can be induced and controlled. The problem of cancer at large cannot here be discussed, but it is enough for us to realise that it will yet become a medical and not

a surgical problem in the individual patient, and that it will be solved not at all by the methods of traditional medicine, but by biology, by the fundamental study of the behaviour, and especially the chemistry, of living cells. The branches of biology called entomology and protozoology have found for us the insects that convey disease; and the protozoa, or humblest animals, that are responsible for such diseases as malaria. Now, the branch of biology called bio-chemistry is in process of solving for us the problems of cancer.

In the United States, we may add, much has lately been done in the way of experiment upon isolated portions of living bodies—a strip of mucous membrane, a fragment of the kidney, and so forth. Clever cytologists have been able to keep these minute living fragments alive for long periods, by means of proper temperatures and suitable nutrient media, and the same has been done for portions of malignant tumours. Thus we are beginning, slowly but surely, to learn the conditions of their growth, and the nature of the nutrient solutions which suit them best and worst. Before very long we may hope to apply such knowledge to the living patient, and to cure him certainly, painlessly, and rapidly—as now and again a patient cures himself, to our astonishment and delight.

It will be plain to the reader that, with the introduction of an efficient chemical antidote to cancer, and of anti-sera and similar bodies for microbic infection, the sphere of actual Listerian surgery in the future will be much contracted. To anyone who has any idea of the subtlety and delicacy of the living body and of the living cells of which it is composed, even the cleanest knife must appear a brutal and barbaric instrument. It is bio-chemistry, or the chemistry of life, that will yearly make this clearer, meanwhile giving us more and more control over vital processes in all their stages. The remoter promise of the future thus excludes the knife altogether from the armoury of the healing art, except in cases of accident. The sole sphere that will otherwise remain for Listerism will be in the care of maternity.



THE DECLINE IN THE DEATH-RATE OF DIPHTHERIA DUE TO THE USE OF ANTI-TOXIN

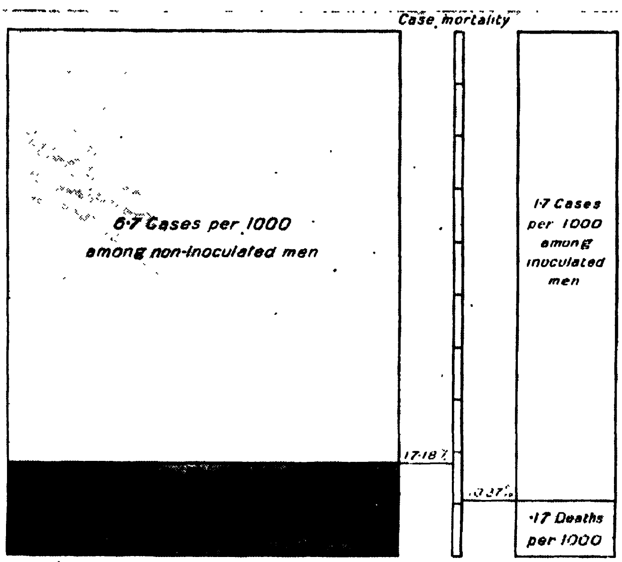
This chart, reproduced by courtesy of Messrs. Burroughs and Wellcome, is compiled from figures obtained from Metropolitan Asylums Board Reports.

Medicine, of a new kind, will return to its place of pre-eminence, as in the days when the surgeon was a barber-surgeon, and the physician was a being of a loftier order. But the physician of the future will merely be the instrument through which his patients profit by the labours of the chemist Pasteur and the surgeon Lister, and one or two physiologists besides.

The great lines of future progress, and the work of the pioneers along those lines, must here be briefly considered. In our study of Health, in another section of this work, we saw that the healing power of Nature, the "vis medicatrix Naturæ" of the ancients, counts for much. This healing power begins to take tangible form in our day. Reference has already been made to the inimitable virtues of thyroid extract in the diseases of mind and body called cretinism and myxœdema. That discovery is now half a generation old, and we naturally have meanwhile sought for similar advantages from the use of other or

Nature's medicaments. The suprarenal or adrenal glands have given us the useful but not actually curative substance called adrenalin. Bone marrow is credited with much value by some physicians. The thymus gland, which lies just in and below the root of the neck in infancy, but disappears almost entirely thereafter, has been employed in various diseases, like the thyroid. The pituitary gland, a curious, small structure at the base of the brain, has been similarly used, in insanity and various other conditions. This gland is enlarged in cases of gigantism. If the enlargement occurs during youth, the subject becomes a giant ; if later, the overgrowth takes a morbid form and the disease called acromegaly is produced. Hence pituitary extract may be employed in order to increase the height.

This by no means exhausts the experiments that are being made in this direction of organotherapy, or opotherapy, as it is called upon the Continent. At the time of writing, none of the results, generally recognised, have been worthy of comparison with those obtained by the use of thyroid extract. That instance, however, proves beyond dispute that a true and fruitful principle is here involved. We shall go on until we find many more applications of it. Extracts of the brain, of the kidneys, the liver, the reproductive glands, the muscles, and so forth, are all being experimented with. Mostly or wholly they fail ; but that may be because our chemistry is not yet delicate enough. It suffices for thyroid extract, which does not fail. The most recent hope is furnished by the gland called the pancreas, which has a great influence upon digestion, and which has lately been proved to influence the utilisation of sugar in the body. When certain parts of the pancreas are diseased, and do not do their mysterious work, the sugar in the blood is not properly employed, and the patient becomes the victim of a form of diabetes. But there are hopes that the administration of preparations of the pancreas may compensate for the lost activity of these cells, just as in the case of the thyroid gland. Other observers in this country, in America, and in Germany, have found reason to hope that the use of the active principles of this same organ may some day enable us to conquer malignant growths, with which they seem to have some connection, according to the German chemists in especial.



HOW THE INOCULATION OF TYPHOID VACCINE HAS BENEFITED THE EUROPEAN ARMY IN INDIA

The total area of the large column on the left represents the number of cases per thousand among non-inoculated men, that on the right among inoculated men. The area of the deeper shaded portions represents the number of deaths per thousand, their ratio to the total areas in each case giving the percentage case mortality shown on the scale.

So much for this line of progress, along which the medicine of the future will surely have much to add to our single established achievement with thyroid extract. Now let us look at the magnificent work that is being done upon the lines which Pasteur initiated. We may conveniently deal with the special studies of the two most illustrious pupils of the French master who survive, now that Lord Lister and Robert Koch have passed away. Those two represented the first generation of Pasteur's spiritual descendants. The first applied the sheer discovery of his master in one field. The second amplified the discovery by adding to the known parasites of disease ; above all, by his discovery of the tubercle bacillus. The men of the next epoch, Professor Metchnikoff and Professor Ehrlich, have neither of them discovered the microbe of any disease. In a sense, their work lies deeper, though that work must, of course, come first.

For, indeed, our science has only just begun when it seems to culminate in the discovery of, say, the tubercle bacillus. Such a discovery closes a long chapter ;

but it opens a new one, just like the discovery of radium and radio-activity, or that of gravitation, or that of organic evolution, or Mendel's law. Plainly, we have now to ask why and how the parasite hurts us, how we resist it, or fail to resist it, and what are the laws of the long process of interaction and combat between the two species, the parasite and the host.

The Science of Immunity the Hope of Future Medicine

The facts are not simple. Two men are both infected with the same parasite—with similar portions of the same culture, or from the same previous patient. One dies, and the other never displays a single symptom. A third man might display grave symptoms, and then recover. Why these differences? Plainly, the discovery of the parasite merely ushers us to the threshold of a new science, which we may call the science of immunity. The converse of immunity is susceptibility, and we combine the study of the two, for they are really one, and the terms are purely relative to one another.

It may fairly be said that the medicine of tomorrow, in so far as it is not simply Preventive Medicine, will be concerned with the practical applications of the science of immunity. The founder of this science is undoubtedly Professor Elie Metchnikoff, the world-famous Russian, who works at the Pasteur Institute in Paris. We have already seen that Pasteur's own theory of acquired immunity was unsatisfactory. It is not true that we become immune because some special substance, which the microbes need and consume, is exhausted, and so they die of starvation. The triumph of the diphtheria anti-toxin proves that immunity depends upon something more positive than that.

The Epoch-Making Discovery of the Leucocytes and the Phagocytes

Late in the 'sixties it had been noticed that the white cells of the blood can pass through the walls of the blood-vessels and wander about in the tissues. This is known as the "emigration of the leucocytes." It is a remarkable phenomenon to observe under the microscope, for we must remember that the wall of a blood-vessel is entire, and that the emigrating leucocyte makes no perforation, and leaves no leakage. But it is a thousandfold more remarkable to interpret, involving, as it does, ideas of purpose in the minute, independent individual cells of our bodies. In the following decade, many workers, including Koch, observed microbes inside certain leucocytes. It was supposed that the microbes, attacking all parts of the body, had attacked and invaded the white cells. No function whatever was at that time known or plausibly guessed for these cells.

In the next decade, the 'eighties of last century, Metchnikoff set to work in the most thorough and final fashion. He proved that the white cells originate in the same part of the body as that which forms the digestive tract, so that we might well expect them to have digestive powers. He proved that, in the water-flea, in which the emigration of the leucocytes was first observed, those leucocytes will engulf and digest the spores of a parasitic fungus, experimentally introduced. He studied the white cells in "a great variety of animals, from goldfish to alligators," and he found the facts to be the same in every case. They were "eating-cells," or phagocytes, and thus he founded the theory of phagocytosis, of which Lister said: "If ever there has been a romantic chapter in the history of pathology, it is the story of phagocytosis."

The Action of the Leucocytes and Phagocytes in Bodily Defence

It was necessary to guard against various possible fallacies. We have no right to assume that the white cells do what they seem to do until we have demonstrated, first, that the microbes do not invade them, and second, that the microbes are not killed, by some other means, before the phagocytes eat them. The process will wear a very different aspect if it can be shown that the phagocytes merely dispose of the bodies of the slain, and play the part of scavengers, instead of soldiers. For if that can be shown, plainly our theory of immunity cannot yet be stated, and we must find the agents which, in point of fact, do the essential killing of the invading host.

Metchnikoff and his pupils met these difficulties in large measure; we shall learn from his great German rival, Ehrlich, to what extent the early criticisms had some foundation. He showed that the phagocytes ate living microbes, which could be recovered and restored if they had not been too long consumed. Latterly, we have obtained evidence to show that the phagocytes do undoubtedly produce and use digestive ferments, which can be, to some extent, isolated from them, and there is no doubt that they do play an essential part in the processes of immunity. This part will depend, in some degree, upon the sheer

numbers of the leucocytes, and, further, upon their particular powers. But it thus becomes a matter of importance to know what is the number of the white cells in the blood of the patient, in almost all forms of disease. In some cases we find that their number is diminished, as in most forms of cancer and in chronic alcoholism (two forms of disease which are known to have some association); and in many other cases the number of leucocytes is increased, producing the state of the blood which is technically known as leucocytosis. This is an alarming phenomenon, or a reassuring one, according as we look at it. It is alarming, as fever is alarming, if we recognise in it an indication of disease; but it is reassuring if, admitting the existence of the disease, we see in the leucocytosis an attempt to counteract it.

Thus, in the victim of the minute double coccus which causes pneumonia, we are glad to observe a high leucocyte count, for we believe that this means a great multiplication of the army of defence, and we know that the failure of the body to produce leucocytosis, when it is attacked by the *pneumococcus*, is of ill omen. Finally, we need only note that the substance known to the surgeon as pus largely consists of dead and dying phagocytes, which have emigrated from the blood-vessels, and have been overwhelmed in the attack upon invading microbes, say, in a whitlow, or in appendicitis, to choose extreme examples.

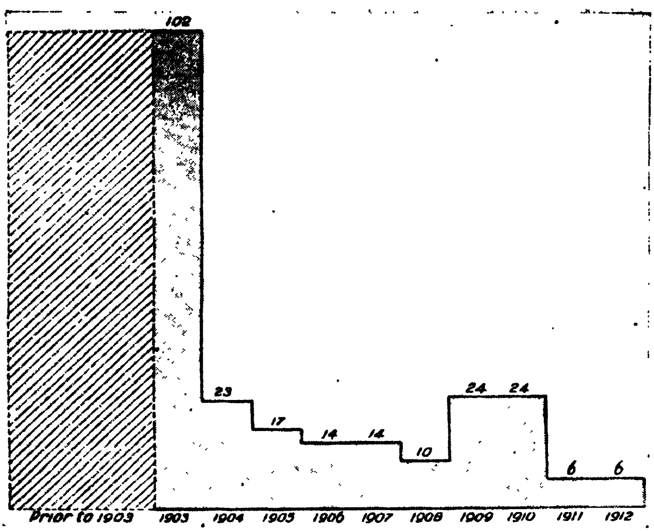
PROFESSOR PAUL EHRLICH

If now we recall the facts of the diphtheria anti-toxin, we see that, notwithstanding the truth and value of the theory of phagocytosis, there must be more for us to discover. Whence and how comes the anti-toxin produced, or found, in the blood of the child, or the horse, in whose body the diphtheria toxin has been at work? Is this anti-toxin produced in the blood, where we find it, by a form of leucocytes? Or is it produced by the cells of the throat, which the diphtheria bacillus is attacking, and is it thence absorbed into the blood? Evidently it looks as if something besides the phagocytes played a part in the acquirement of immunity in this case.

Long ago, we remember, the ancients had a *humoral* theory of disease, according to which certain humours, made in the body, affected its condition, and that of the mind—as when we say, "It is his humour," and hence, "I humoured him." This ancient view is now to be revived in a new form, for we can demonstrate the existence of fluids or humours in the blood, which determine, for instance, our recovery from disease. The question is, how far does such a discovery qualify the phagocytosis theory? We can prove that the fluid part of the blood contains substances which kill certain germs. For nearly thirty years it has been known that the ordinary blood serum of a rabbit will kill anthrax bacilli. In other words, the blood serum is antiseptic; *not*, be it observed, in general and at large, as carbolic acid is, but specifically antiseptic towards certain microbes. These substances in blood serum which kill bacteria may accordingly be called *bactericidal*, and evidently we must add a recognition of them to our theory of phagocytosis. When we do so, it is open

to Metchnikoff to reply, as he has done, that these bactericidal substances in the blood serum—the fluid part of the blood—have been produced by the phagocytes, and have overflowed into the serum from them. That may be so.

Already we have gone far enough to understand certain facts. In many instances, when parasites attack us, we are either not made ill at all, or else we suffer very little, and are speedily well again, though those parasites have never attacked us before, and though certainly nothing the doctor gives us has made any essential difference. We have, in some degree or other, a *natural immunity* against the attacks of that kind of parasite; and this immunity may be traced to the presence in our blood, first, of phagocytes, and, second, of bactericidal substances (however produced) which kill the invaders. This question of natural immunity has been almost wholly ignored by bacteriologists and doctors, and very excusably so. "The whole need not a physician." The urgent problems are those of the patient who has not natural immunity enough, and our intensest interest is bound to centre in the problems of *acquired immunity* for such patients.



RESULTS OF THE TETANUS ANTI-TOXIN IN THE UNITED STATES

This diagram shows graphically the results of a campaign instituted in America in 1904 to reduce the number of cases of tetanus resulting from accidents during the Fourth of July celebrations by the sufferers taking doses of the anti-toxin. The figures over the columns represent the cases of tetanus per thousand cases of injury.

But from the point of view of Life, and general biological problems, natural immunity is one of the most fascinating subjects in the world. For how was it acquired? Whence the presence of these admirably fitted substances in the reader's blood, exactly *made* to checkmate certain microbes, which his body has never experienced? His body was developed from a single microscopic cell, and somehow, somewhere, in the structure and potentialities of that "zygote," were the antecedents of this bactericidal serum, which no ordinary chemistry can imitate. It seems hopeless for us to form any theory of the presence of such substances in the blood, unless we invoke a certain theory of heredity, which is in very poor favour at the present time. We seem compelled to argue that the parents (or one parent) of the individual have suffered from this parasite themselves, that a bactericidal substance has been produced in their blood serum, and that this *acquired immunity* of theirs is handed on so as to become *natural immunity* in their offspring. In other words, here we are accepting the famous Lamarckian theory of the "transmission of acquired characters."

The neo-Darwinians will have none of such a theory. They admit that races appear to become resistant to many diseases in proportion to their experience of them, but they deny that this immunity is due to the natural inheritance by offspring of a character painfully acquired by parents. They explain the facts in another way. They say that individuals vary naturally in their resistance, by pure chance, and that natural selection, working by means of the disease-parasites constantly tends to weed out from each generation those individuals whose natural immunity is low, while those whose natural immunity is high survive, and hand on their natural, *not* acquired, trait to their offspring. The practical importance of this controversy is transcendent, for if the neo-Darwinian view be correct, the only way in which to get a race that can resist, for instance, tuberculosis is to let that disease run riot for as many generations as need be, until all the susceptible stocks are weeded out, and the resistant remain. On this view, all the objects and methods of preventive medicine and all the devices whereby doctors keep their patients alive, are futile, and worse, leading only to the perpetuation of

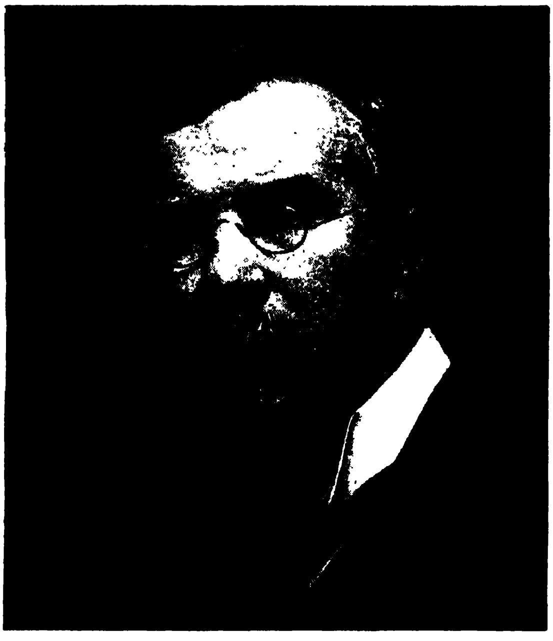
susceptibility, and, therefore, of disease (whenever the parasites get a chance at all), in future generations.

Here we regard this view as false, and we reject it, as the majority of contemporary students are coming to reject it, on the ground that the neo-Darwinian theory of the *chance* origin of immunity is incredible. We find the bactericidal substances, and the whole machinery of defence, in the body, to be so subtle, exquisite, complicated, exact, that the theory of its origin by sheer chance, without any reference to its purpose, is ridiculous. It would be much easier to believe that a relatively simple thing like a motor-car had fallen together by chance, though not even the neo-Darwinians could be so credulous as to believe that.

But what of acquired immunity, for therein will centre the medical achievements of the immediate future? Here our great master is Ehrlich, of Frankfort. To him we have recently been indebted for the organic compound of arsenic which kills the parasite of syphilis, and which, being number "606" in the list of substances which he experimented with, is often known by that number. This discovery, which has already been of the utmost value, must be directly traced to the discovery of the parasite of syphilis by Schaudinn, for it was the study of the chemical substances which most markedly affected this parasite outside the body that led to the construction of "salvarsan," or "606," for its destruction inside the body. This discovery has made Professor Ehrlich's name familiar to all readers, but it has long been honoured by students of disease for his celebrated "side-chain" theory of immunity.

This theory is much too complicated for discussion here, but it explains the proven fact that at least two substances are required in the blood before immunity can be established. One of these kills the microbes, but the other has first been necessary in order to make the microbe vulnerable. It holds on to the microbe with one hand, so to say, and holds on to the deadly bactericide with the other, and so links the two together. To this substance Ehrlich has given the name of "amboceptor," or two-catcher. The antitoxin of diphtheria is doubtless an amboceptor, holding on to the bacillus with one hand, and introducing the bactericidal substance in the serum to it with the other.

Lastly, we have the interesting observations of our own bacteriologist, Sir Almroth Wright. He believes that he has discovered in the blood serum a kind of substance which he calls "opsonins" —*i.e.*, cookers—which, so to say, cook the microbes before the phagocytes can eat them. On this view, the phagocytes are of small importance, and it is the opsonins that matter most. It is supposed that the condition and the prospects of the tuberculous patient, for instance, can be estimated by counting the number of tubercle bacilli that his white blood-cells will consume in a given time, for this is supposed to furnish an index of the opsonic power of the particular blood serum in which the experiment is conducted. Among substances already proved to be useful, which have been obtained by such studies as these, we may point to the anti-diphtheritic serum, and to the anti-tetanic serum, which has often succeeded against tetanus, or lockjaw, the anti-typhoid sera, invented by Wright and others, the anti-streptococcic serum, often valuable in erysipelas and puerperal fever, and the anti-staphylococcic serum, often valuable in cases of boils and abscesses. The record is a good one, but it is vastly more promising than it is good. Great things are before us, thanks to the principles which we owe to Pasteur, Metchnikoff, and Ehrlich.



SIR ALMROTH WRIGHT, THE GREAT BACTERIOLOGIST
Photograph by Histed

MAN'S INROADS ON THE FOREST PRIMEVAL

A CLEARING IN A FINLAND FOREST, SHOWING THE RESTOCKING WITH YOUNG TREES

A TYPICAL SCENE IN THE FOREST BELT BEYOND THE ROCKY MOUNTAINS

THE COMMUNITY OF TREES

Methods Used by the Forester in Preserving and Extending the Growth of Timber

ARBOREAL STRIFE FOR LIGHT AND LIFE

In our last chapter we purposely left the consideration of the subject of trees for the concluding portions of our study of the life of plants, and we may end our study with a brief glance at some of the more interesting points which may be observed in communities of trees. It is especially communities such as are usually termed forests that we shall consider here, a term that may be defined as an extensive, uncultivated tract of land more or less covered with trees. For the best examples of the real forest life we have now to go to newer countries than our own, and especially are these forests seen in perfection in such places as America and Canada, where the timber industry is an immense one.

Let us imagine ourselves, for the moment, transported to one of these countries where we could examine at our leisure the interesting forest features, and we may presume that we find ourselves at the edge of a forest on a fine day in the late autumn. We probably approach the forest through extensive pasture lands of grass, then reach vegetation of the character of shrubs, and then, almost in a moment, we enter into a different environment altogether. We have passed suddenly from heat to coolness, from bright sunshine to lofty, shaded paths. Under the magnificent oaks, elms, and beeches we find no longer the grassy carpet of the pasture, but a floor peculiar to the forest itself—one of leaves, which lie in a thick layer. Others which have not yet fallen form a perfect roof overhead.

The forest is an untouched one, and innumerable trees all around us are seen to measure on an average over two feet in diameter, and the height of some cannot be less than two hundred feet, so that the experienced forester would realise at once that these giants were not less than one hundred years old. Here and there it is evident that an individual tree has never had a chance. It is either injured or small, and has evidently suffered in the struggle for existence at the hands of some more sturdy and successful neighbour. Still others are dead, or dying, and so we reach the conclusion that one of the features in the forest is that many trees do not reach maturity on account of being crowded out, and hidden from the sunshine and light. That this is the truth is obvious from the fact that there is plenty of room on the ground, although the young trees are conspicuous by their absence. We see them only where an old stager has come to grief and let the light in. In spite of this, these trees which occupy the ground have been producing seeds year after year, but the shade and lack of warmth have forbidden their growth. Those that have succeeded under these conditions will be chiefly the maples and the beeches, which can evidently survive better than the oak and the elm in like circumstances.

Here and there we come across the stump of a tree which has obviously been felled last year. It exhibits the annual rings, of which we spoke in our previous chapter, and, counting them, we may possibly find that there are eighty or so. A closer observation elicits the interesting fact that the rings are broader from about the thirtieth onwards, up to the seventieth perhaps; and this teaches us that the last growth was not so good. The tree reached its prime and grew well. It got more light and heat. The last few rings were narrower again; the tree was aged, and growth diminishing. The signs of age and decay differ very much in the different kinds of trees in the forest. The poplar is

evidently near its end at 150, while the cypress flourishes to the age of 500, and others of the so-called "big trees" are estimated to have started their career before the beginning of the Christian era.

Other signs of the incidents of forest life meet us on every hand. Here is an old oak with a patch of quite smooth bark in the midst of the rough. There has been a healing process here. It represents the spot where a branch broke off, and the new skin, or bark, has formed over it. But here is another mark, evidently where another branch broke off; but instead of there being a smooth covering, a hole is left in which the squirrel makes a nest. The wood in this case was too ragged to be healed. Still other marks on the bark attract our attention as we walk along, and some of these we notice are in pairs, one on either side of the trunk. These have evidently been made artificially by man to mark the tree, so that it can be recognised at will. Such marks are termed "blazes."

We turn our attention to the ground for a moment, and scrape on one side the covering of leaves, the freshest ones being on the top, and the submerged ones in all stages of decomposition. Under them lies what we learned early in our study to call the *leaf mould*, and under this again the soil proper, or *loam*.

A PATH THROUGH A COPPICE WOOD BESTREWN WITH THE FALLEN LEAVES THAT MAKE RICH SOIL

Scattered about wherever we go we see the broken-down wrecks of dead trees which have failed in the struggle, and, dying, have been blown down and exposed to the action of wind and weather. So we find them in all stages of disintegration. They serve as a lodgment for an infinite number of smaller forms of plant life, such as ferns, mosses, and fungi, the latter helping on the process of decay. Presently we come to a more or less open patch, where the light gains free access and the outer warmth can penetrate. The result is seen in the large number of quite young trees, all of which are starting their career. They, in their turn, will be eliminated as the strongest survive. We may find as many as eight of these youngsters in a square yard, and whenever such crowding occurs they rapidly increase in height rather than in breadth.

Such would be some of the most interesting observations we could make on strolling through a typical forest on a soil of loam, and such forests are common enough in the countries we have mentioned. If we were to go to other countries, however, where the soil was sandy we should find forests of a very different character. Instead of the mixture of ancient trees of the broad-leaf type, we should find that, covering the sandy ground, the forests are practically all of pine. This is not a question of climate; it is a matter of the character of the soil. So we usually find that the luxuriant mixed forest is growing on a soil which is of the character of a fertile loam or clay; while the sandy soils are usually restricted in the character of their trees to the pine class.

But the soil on which a forest grows does not remain unaltered continuously. All that the forest trees extract from it are moisture, and the various kinds of organic salts which are in solution. As we have previously seen, the tree manufactures its own nourishment other than these substances from the air. The salts so extracted from the soil—or the majority of them—are not lost to it, for they return with the fall of the

leaf, once more to be incorporated in the soil as the leaf decays and is dissolved. So that in this way there is a continual exchange between the trees and the soil. The latter, however, changes its character from the additional matter added to it by the leaves and their contents annually falling, and gradually producing a fertile leaf mould on the surface of the soil. Hence it is that forest land, when it is first cleared, is so extremely fertile. The soil, therefore, in the first place, determines the kind of forest that will grow upon it; and then, secondly, the forest itself contributes to the improved fertility of the soil.

The character of the soil, however, is not the only thing that influences the kind of forest produced. If we were to travel through a moist, damp district which gradually changed into a hot, dry one, we should find that, in spite of the character of the soil and the altitude remaining the same, the type of forest would change very materially. We should pass from the thick, dense, mixed forest through that of pines, gradually into sandy wastes. The change here would be due not to soil characters, but to the variation in the amount of moisture present. A deficient rainfall acts by restricting the number of species of trees which will grow in any given district, the elm and the ash soon disappearing. The oak will last longer, but eventually goes, too. In fact, dryness acts very similarly to sandy soil, and when the two are combined the

A GIANT TREE WITH A GIRTH OF 108 FEET IN THE NATIONAL PARK, CALIFORNIA

effect is naturally more marked. On the other hand, an excess of moisture is almost as fatal, for it can be observed that where trees become submerged at their roots they do not long survive Wet soils, therefore, reduce the number of species.

Temperature, too, plays a very important part in determining forest growth. With a long, severe winter on a fertile loam the forest will probably consist of a mixture of hard-wooded trees and pines, the former predominating. The southern shores of Lake Superior exemplify this. The milder climate of Indiana has a virgin forest of oak, mixed with other broad-leafed trees, but no pines. A still warmer district, such

What about altitude as a factor in forest life? As one would naturally suppose, the forest will become more and more restricted in the number of its species the higher one goes, and this we should expect from the influence of cold. The exposure of the tops of mountains tends to produce stunted trees, and the forests, where they exist at great altitudes, are chiefly those of the pine. The variety of the forest decreases the higher one goes, as does also the growth of individual trees.

Such are some of the factors which cause forests to vary in their appearance and composition; and we may now turn our attention to questions relating to forestry

A PLANTATION OF YOUNG PINES ON THE BORDER OF A PINEWOOD

as North Carolina, shows the poplar and the chestnut predominating, and the pines once more. And when we reach Florida, where frost is practically unknown and the orange and the pineapple flourish, the forest, though still containing many oaks and ashes, has added to it the palm-tree, a species that at once gives an entirely new aspect to forest appearance. We have passed from forests of few species and small trees; many species of magnificent specimens; still more species equally good; finally, to a sub-tropical flora; and all this change of forest aspect is a matter of the alternations in heat and cold

itself, noticing briefly some of the general principles involved in the artificial raising of a forest, or in the keeping up of one naturally produced.

There are at least six principal methods of production, or reproduction, of forests.

There is the method known as the production of a coppice wood, in which all the large trees are cut down, and where the production of timber is due to the sprouting of what remains. This coppice method is suitable only for the broad-leafed trees especially the oak and the chestnut, and succeeds where there is a mild climate and a soil of at least average fertility.

Then there is the method known as the standard coppice, in which the forester, instead of cutting all the trees, leaves from fifty to one hundred or so of the very best on each acre of forest. These, in their turn, are cut some thirty years or so afterwards — that is, when they are at least sixty years old, and have lived through two rotations of a coppice wood. They are then termed

A VISTA NEAR MILFORD SOUND, NEW ZEALAND—BARE MOUNTAINS SEEN FROM SYLVAN VALLEY

standard. Some may be left for a third or fourth rotation. In such a wood the main crop of timber comes from the sprouts, the large standards being raised from seeds or plants. The timber from the sprouts is of the same kind as that in the ordinary coppice, while the standards include the oak, the ash, the chestnut, and also the pine.

Thirdly, we have what is known as the method of selection—a very usual manner of producing a timber forest. In this we have all the varieties of trees which flourish on the particular soil and in the special climate concerned. The trees have usually been started from seeds, not sprouts. Each year the forester *selects* such of the trees as, in his opinion, require cutting out, either because they are ready for the market or because of the necessity of thinning.

One of the drawbacks to the method just quoted is that many good young trees may be injured by the felling of larger and older trees; and to meet this objection, and some others, the following modification is sometimes adopted. The area of forest is cut

two, three, or four times in from ten to twenty years. The first cutting merely thins out, while the second leaves the trees growing from seed, which get more light and warmth at the third cutting. The final cutting removes the last of the old trees which are left. All the different kinds of trees in this method are constantly reproducing themselves by seedlings during the whole period. It can be used in any climate, and is especially a serviceable method in the more exposed forest situations.

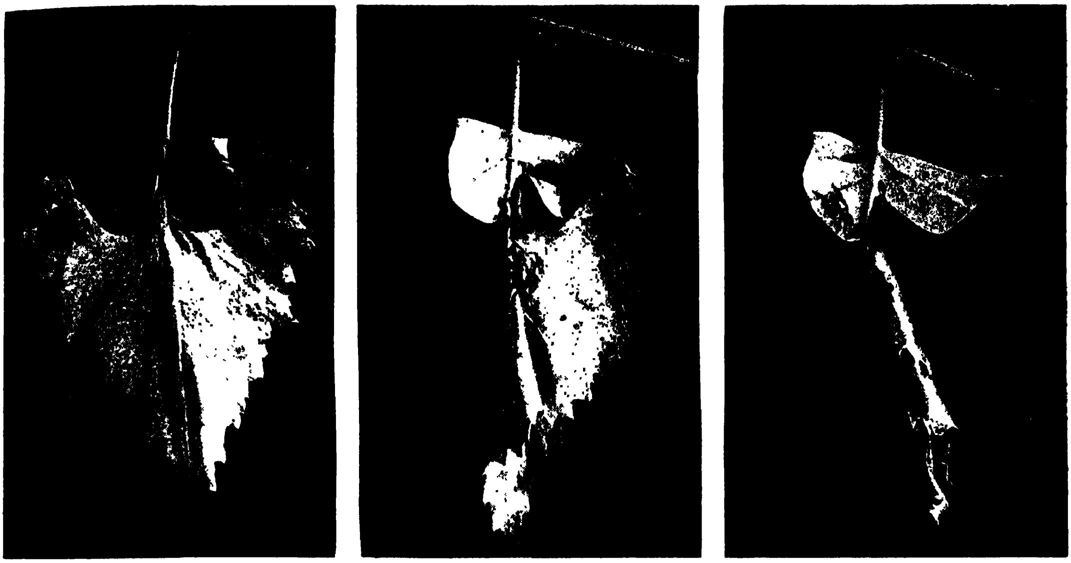
In the next method, the ground in which the new trees are produced receives its seed on one side of the forest growth, instead of under the seeding tree, and is therefore termed *seeding from the side.* The method of procedure is to cut down all the trees along a strip which is from fifty to seventy-five yards wide, leaving this until it is once more covered with young seedlings. Then to cut another strip, and so on until the entire forest area has been dealt with in a similar manner. Such cleared forest land is replanted by seeds carried by the wind, so that the selection of the strip to be first dealt with should be determined by the prevailing wind of that particular district. The seeds themselves are, of course, brought from the trees of some neighbouring forest. The method is therefore only suitable for the production of trees that have light seeds, such as the elm, birch, poplar, pine, and some others, and it is most suitable in warm climates with an abundant seed production. It is not a common method in Europe, because, after cutting the strip, the soil becomes too quickly covered with a coarse growth of grass, weeds, and brambles, but it has been used with very great advantage in the pine forests of America, and in the fir forests of the Pacific Coast. It does away with the necessity of marking the trees ; it prevents young growths being injured ; and is also cheaper than some other methods.

THE TUNNELLINGS IN PINE BARK OF THE HYLESINUS PINI

Finally, there is the method of starting the forest by artificial planting, or sowing, of the species required, which is, of course, the ideal method for producing a symmetrical forest growth of any desired species of tree. All the trees can be grown so as to be cut at one and the same time at the required age and size, and the method is applicable to all sorts of forests and to all sorts of soils and climates. It simplifies the work of forestry, reduces the cost of removing the timber, and prevents the inevitable crowding of young trees which occurs when the forest is left to its own devices. Its advantages are therefore obvious.

The operations of forestry, however, include a great many more processes than that of simply planting the forest, even though that be an all-important matter. For example, suppose that a pine forest has been planted in which the young trees are some five feet apart from each other. They will give the appearance of having at least twenty times as much space as they require, but if the observer were to see the same planting at a subsequent date—say, after an interval of some five years—he would observe that the tops of the branches were already beginning to touch each other. If he were to return after another ten years had elapsed, he would be struck with the fact that the trees were at least twenty feet in height, and almost entirely devoid of lower branches. He would have before him a splendid object-lesson of the struggle for existence in plant life, together with a striking illustration of the truth of the great principle in Nature that the fittest survive. Before him he would see the weak going to the wall, and not only being crushed out of existence themselves, but also acting in a detrimental manner to their successful rivals by absorbing moisture and food which might be utilised by others. After a still further lapse of time there will be quite a number of dead and dying specimens, but the survivors will be large, well-grown trees in a better condition. True, there

will be but few lower branches; and it will be quite obvious that some artificial help is required in order that the pine forest originally planted may give the best result. The forester, therefore, adopts the process known as thinning and cleaning.



A WEEVIL AT WORK CUTTING THROUGH AND ROLLING A BIRCH LEAF TO LAY EGGS IN

As a matter of fact, it would have been well to have thinned at intervals of ten years, repeating this process when necessary, so that eventually "there ought not to be left more than ten trees on one square rod at the age of twenty, four at forty, two at sixty, and one at a hundred years." A very general guide to the forester in these matters is his observations of the crowns of the trees, the thinning out being done to such an extent as just to prevent these from touching. Such trees as can stand a good deal of shade need less thorough thinning; but the principle of thinning is all-important, and requires great experience in order that it may obtain the best results.

A PINE WEEVIL FEEDING ON A YOUNG PINE SHOOT

The young forest has to be protected against other injurious factors besides its own overcrowding. It may be necessary in some situations to take precautions against fire and storms, but more dangerous still, perhaps, is the risk run by the trees from the attacks of various insects. It is recorded that the bark-beetle ruined more than 22,000 acres of spruce in Bohemia in 1870 and the following year. The caterpillar of the nun-moth ruined over 260,000 acres, involving more than 4½ million cords of timber in Prussia between 1853 and 1863. In America the gypsy-moth has involved the State of Massachusetts in the expenditure of an immense sum of money to combat its ravages. When we remember that a bark-beetle of one year may produce about half a million before the end of the second year, and that a leaf-eating moth may produce some 400,000 descendants in three years, one can gain some idea of the immense power for destruction that insect life has for forests. Then we have a number of caterpillars which kill the young trees by eating the leaves and spoiling the buds; weevils which destroy the young plants of the pine, for example, not to mention the underground insects that attack the roots of various trees. The worst insect enemies are the bark-beetles, the grubs, and the caterpillars of moths and butterflies.

The bark-beetle bores through the bark, and deposits in her track from fifty to a hundred eggs. The grubs which hatch out continue the boring process in all directions. In the dust it produces it hatches into a beetle, which again begins boring either in the same or other tree; and so the process goes on. The moth does its damage in a different manner. Laying its eggs in the summer, these hatch in the following spring, and the caterpillar produced proceeds to feed upon the leaves of the tree in question. Then it spins a cocoon, from which presently it changes into a pupa. It is only in the caterpillar stage that the moths do their damage. Some prefer the hard-wooded trees, conifers, while others do not restrict their attention to any special kind, and some feed only upon one species of tree.

These enemies of forest life require to be destroyed as far as possible, first of all by keeping the woods well cleaned and thinned; and, secondly, by seeing that all kinds of birds which feed upon insect life are encouraged, as well as other animals, such as shrews, moles, and bats. Among larger forms of life, some enemies to the forest are to be found in the rodent family, especially among mice, rabbits, and squirrels, the latter of which may eat the seeds, while the mice and rabbits gnaw at the bark. Grazing animals, too, may do considerable damage by devouring the young shoots, and so spoiling the growth of the tree. The very lowest forms of life, such as fungi, also do considerable damage, despite the fact, which we have previously noted, that they are useful in the destruction of fallen timber. If they did that only, it would be all right, but, unfortunately, they may spread their operations to the wounds of otherwise strong trees. Finally, in connection with the enemies of the forest, it is stated that in some places even the parasitic mistletoe is an important factor in destroying much of the oak timber.


THE BARK OF A HOLLY TREE GNAWED BY RABBITS

In another section of this work (pages 2655-2671) we have dealt fully with another side of the subject of forestry, to which we would direct the attention of our readers. We may therefore here conclude our remarks on the subject by reminding ourselves what the forest has meant to man. To primitive man, of course, the forest was all-important. It provided him, first of all, with shelter, then with fuel, and, finally, with food. Those functions, vital as they were at one stage of the world's history, are no longer borne by the forest of today. True, to a large extent, the forest still supplies our fuel, and also the material out of which we construct buildings for our shelter; and, of course, had it not been for the products of the forest, it would not have been possible for the Phœnicians to sail the North Sea, nor for Columbus to start on his famous voyages. Even today wood plays an immensely important part in the shipping and other means of communication which are so notable a feature of modern life; and though we may travel more by rail, still it is not to be forgotten that every iron rail rests on wooden sleepers, and almost every single kind of merchandise carried by trains and ships is either packed in wood or protected by some wooden structures. All our exquisite furniture comes from the forest; and perhaps the most romantic process of all modern forest developments is that associated with the production of paper. Even a coal-mine depends for its economic working upon timber, so that the ancient fuel is really a necessity in the production of the modern.

As a simple matter of fact, there never was a time in the history of the world when the products of the forest were so varied and necessary for the comfort of mankind as they are today. A bare list of the natural products of the trees of different species, and the manufactured articles from the denizens of the forest, would occupy many pages.

A LIFE OF AGES AND THE MIGHT OF A MOTH

These three pictures show how the mighty ash-tree may be eaten up and finally overthrown by the larvæ of the goat-moth, shown on the next page. The top right-hand picture is a near view of a trunk shown on the left, and shows the destruction by the insect.

THE GOAT-MOTH THAT DESTROYS BIG TREES

THE LARVA EATING THROUGH A BRANCH

ITS WOOD-DUST COCOON PRIOR TO PUPA STAGE

THE MOTH JUST EMERGED FROM ITS CHRYSALIS

THE MOTH READY FOR ITS FIRST FLIGHT

The photographs on this page and pages 4057 and 4060 are by Mr. J. J. Ward; others on these pages by Messrs. Hinkins & Son and Underwood & Underwood.

SOME WINGED BEAUTIES

The Butterfly's Painted Splendour and the Dragon-Fly's Shimmering Mail

THE SECRET OF THE FIREFLY'S RADIANCE

When we look at the towzled fleece of a Southdown ram, and then at the radiant glory of a butterfly's wing, we have to admit that Mother Nature has not yet much to learn from the craft of man, her insurgent son, in the matter of wizard transformations of material. The wool of the sheep, the spines of the porcupine, the prickles of the hedgehog, and the horn of the lusty rhinoceros are all cousins to the miracle on a butterfly's wing. The colours on a butterfly are derived from scales, which break and refract the light into the incomparable patterns that delight the eye. Those scales of the butterfly, equally with the wool of the sheep and the formidable weapon of the rhinoceros, are but highly modified hair. Spenser's was a beautiful conception of the butterfly's rainbow mantle :

> The velvet nap which on his wings doth lie,
> The silken down, with which his back is dight.

But Linnæus for ever fixed the definition when, finding that the "velvet nap" is really a series of minute scales, he called the order to which butterflies and moths belong Lepidoptera, or scale-winged.

It was formerly believed that this sculptured mail served only the purpose of adornment, but there is more than that in these minute overlapping marvels. A rose without its perfume would be robbed of half its charm, and it doubles the interest in the butterfly to know that concealed among these tiny scales are exquisitely formed plumules which distil sweet scent. The presence of these specialised scales was long known, though their purpose has only latterly been clearly determined ; and it remained for Dr. F. A. Dixey, at the British Association in 1911, to show how complicated is the system under which they discharge their functions. The scent-plumules are present only in the males of certain species, and in some are distributed generally over the surface of the wing, while in others they are collected into certain circumscribed areas. Dr. Dixey cited, as instances of the latter, the male of our common clouded yellow butterfly, and a tropical relative of our common brimstone butterfly. To these may be added examples such as the fritillaries, in which the scent-scales are placed on one or more of the middle nervules of the fore wing ; the meadow-brown and its kindred, which have them on the disc of the fore wing ; the skippers, which have these specialised scales in well-defined patches, but varying with species. Dr. Dixey finds that these scent-tracts are in many cases furnished with a supply of ramifying trachæa, microscopic air-vessels, derived from larger air-vessels running in the so-called veins or nervules of the wings. On reaching the scent-patches the main air-bearing trunks break up into minute branches, where it is conjectured they serve forcibly to disperse the scent through the scales into the outer air. Let us, however, consider more in detail the life-history of these remarkable insects, with which we open our chapter on some of the winged beauties that gladden the eyes of mortals.

The first stage is, of course, that in which the embryo develops within the egg. The eggs of moths and butterflies are among the most beautiful of all eggs, exquisitely shaped and coloured, some distinguished by the most delicate of shades, others gleaming opalescent. Certain naturalists seek to establish a system of classification by the eggs alone, but the scheme is impossible. The eggs are deposited by the parent insect upon the leaf of plant or tree which will constitute the food of its larvæ.

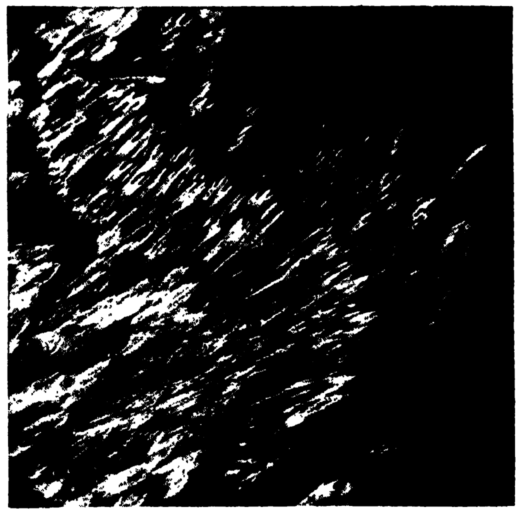
This is one of the most striking triumphs of instinct. The larvæ are strong-jawed devourers of tough vegetable food, or, in the case of the clothes-moth caterpillar, of hair and woollen fabrics. The perfect insect when it feeds does so by a beautifully adapted suctorial proboscis. It knows nothing of the matter of food from solids. Yet every moth and every butterfly will, at the time of egg-laying, seek out the very plant upon which it is natural for the larvæ of its species to feed. The offspring never see their parents, the parents do not see their offspring, yet here is this invariable law in operation, this unfailing choice of the very food supply in which the caterpillar should be cradled.

Be it noted that whereas the majority of caterpillars, taken at birth, can be reared

THE EDGE OF A BUTTERFLY'S WING

upon practically any non-poisonous leaves, very few caterpillars, once they have begun their career upon a certain form of food, can be induced to change it. Most of them will die of starvation rather than submit to a change of diet. The moth or butterfly which has been reared from the egg in captivity upon a food different from that which the members of its species naturally take will, when liberated and mated, seek its nursery in a vegetable growth similar to that upon which its parents hatched. The eggs are placed, then, in such a situation that, at the appointed time, the larvæ, upon emerging, will find themselves surrounded by food—home and food, indeed, are one.

Hatching from so tiny an egg, the caterpillar, a mere tiny streak of life, naturally contains small reserves of food supply; and the first thing it does, after recovering from the stress of bursting from its cradle, is to eat the latter. So small are the newly hatched caterpillars that, as they lie quiescent upon the shells of the eggs they have left, the observer requires a magnifying glass to assure himself that it is life, and not the discoloration of the eggs, that he sees. But the small grub has brought well-developed jaws with it into the world; and, whether it be cradled on the tender leaves of the dead nettle, upon the foliage of a delicate plant, or upon the tough leaves of privet, those small but powerful jaws soon relieve the observer of doubt as to the life-force that impels them to their work. Like a horse of morbid appetite which eats its bed, or the hateful grub within the living flesh of its animal host, the little caterpillar



THE TIP OF A BROWN MOTH'S WING

devours its home. That home may be within the trunk of some stout tree; it matters not, the caterpillar gnaws the wood as easily as its cousin bites its way through a cabbage-leaf.

The caterpillar is a sort of Fat Boy Joe of insects; it lives to eat, but with better excuse than the ample hero of the Wardle household. From the day of its birth it has to accumulate food reserves, not only for its larval life, but for the life which follows its wondrous change from crawling thing of lowly life into the winged gem of the sunlight. The day is coming in which jaws will vanish, and no solid food be taken. With this almost incessant feeding the caterpillar simply grows too big for its skin. It lapses into torpidity, then casts its skin and alimentary canal. The whole investing

integument is sacrificed. The caterpillar must jump out of its skin. It emerges by way of a slit at the back of the head, crawling through, and leaving behind the covering of head, body, legs, and claspers. A weak and weary caterpillar issues, limp and flaccid, with jaws as soft as putty. The grub rests, exhausted; and as it rests, its mandibles harden, strength returns to the entire frame, and, with strength, appetite. Feeding is renewed, and another development of growth promoted.

The varying stages of growth alternate with successive moults. These may number but five, or they may reach twice that total. The transformation from the egg to the pupa stage may be completed within a month or six weeks, or, as in the case of the goat-moth (Cossus ligniperda), it may extend over three years, during the whole of which time the great, malodorous caterpillar is eating its way through the heart of a tree-trunk. An equally large caterpillar, that of the privet hawk-moth (Sphinx lingustri), which has a very much wider range of diet than its popular name implies, may run all its larval course during a summer, though it is to be surmised that only when it obtains a certain minimum food supply is its metamorphosis thus expeditiously effected, for it is by no means rare for the caterpillar to avoid the pupal stage until the following summer, while a great number may pass the winter in the chrysalis stage. The importance of diet to the life-history of the caterpillar was brought home to the present writer by an experience so singular as to be worth relating.

VAPOURER MOTHS LAYING THEIR EGGS

Two wingless females are here seen resting on their cocoons, from which they have emerged, and depositing their eggs. They usually die among their eggs. The males only are winged.

A fine example of tiger-moth, caught and carefully handled, deposited, on the sides of the box in which she was confined, 252 eggs; then, of course, died. The eggs hatched in the usual way, and the caterpillars, regularly fed, ran a normal course until the end of September. Then their owner was absent for a fortnight, and their feeding was overlooked—an unfortunate incident, without precedent or parallel in that household. After their fortnight's privation, the caterpillars appeared at first sight to be dead, but were not. They all refused to feed. They remained in this state of torpor for over two months, gradually becoming more and more attenuated and "wilted" in appearance. At Christmas they seemed past praying for, but food was offered them once more—tender leaves of lettuce grown under glass—and they began to feed again, after over two months of fasting! They fed all through the remainder of the winter; and as many as were permitted by their owner to complete their cycle reached the pupal condition, and emerged in due season resplendent moths. After an autumn fast, they had passed the winter in the caterpillar stage.

Proceeding, then, from the particular to the general, we may infer that when the caterpillar, which should become a chrysalis in a matter of a few weeks or months at most, remains in the larval condition for nearly a couple of years, such caterpillar has not, within the lesser time, stored sufficient energy to enable it to undergo the prodigious change which awaits the fully developed larva.

The alternating activity and quiescence of the caterpillar—the voracious feeding followed by the lassitude and enfeebled contion associated with the casting of the skin, are a prophecy of the pupal stage. But the change effected is very different. What kind of creature is it which sloughs its skin in order that a newer one may enclose its expanding frame? It is composed of thirteen segments, of which the head is one. Its skin may be smooth, or hairy, or spiny. The three segments immediately behind the head are each furnished with a pair of true legs. These three segments correspond with the thorax of the perfect insect, from which will burgeon the three pairs of legs and the two pairs of wings. The remainder of the larval body corresponds with the abdomen of the imago, and is equipped, as a rule, with four pairs of false legs—pro-legs, as they are called—and a pair at the rear, which act as claspers. The sequence and number of the pro-legs are varied in the larvæ of the geometrician moth. This caterpillar, which is known as the surveyor and as the span-worm, has but two pairs of pro-legs, so that, instead of progressing with the undulating motion of the ordinary caterpillar, it arches its body; then, gripping by the claspers and pro-legs, throws the fore-part ahead, holds by the true legs, and finally draws up the hind part.


TWO WHITE, OR CABBAGE, BUTTERFLIES

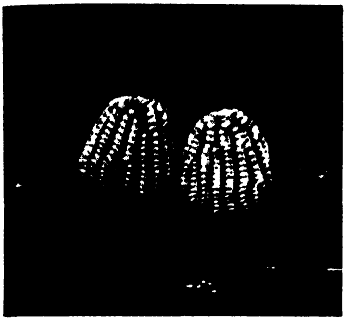
A succession of tiny orifices may be detected along the two sides of the caterpillar. These are the spiracles, the small breathing-tubes and are the only external organs which reappear in the adult insect. By means of these spiracles, air is admitted to every part of the body. They reappear in the chrysalis, along whose chitinous sides they are more clearly perceptible. If the moth is to emerge from the chrysalis it is necessary that these spiracles should be guarded. The present writer lost a fine specimen through placing a chrysalis in a box of bran for the winter with a number of mealworms. The latter reduced much of the bran to a fine powder, which clogged the spiracles of the chrysalis, and caused the moth to die within its shell.

The head of the caterpillar is a complicated mechanism. It is furnished with small antennæ and minute palpi—delicate tactile organs which are probably of greater importance to the caterpillar than its eyes, whose power of vision is small. The jaws or mandibles are powerful, and it is interesting to note that an industrious microscopist has discovered three pairs of breathing-spiracles here.

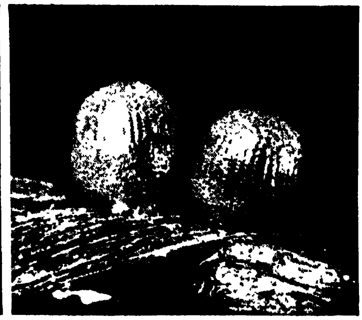
Beneath the jaws lies the spinneret, by means of which the caterpillar spins the silken threads with which to suspend or immure itself. So far the common outline of the larva, which, at the given time, passes as it were into a trance, to emerge a thing of wonder and beauty. It would fill a volume to describe the many different forms assumed by caterpillars of various species, their habits in life and in preparation for pupation.

Many of them are vividly coloured and beautiful—the delicate green ground and lateral whites and heliotropes of some of the hawk-moth caterpillars are exquisite; and though the colouring is conspicuous enough when one holds the caterpillar on his hand, it harmonises so well with the insect's surroundings that the larvæ are difficult to find, even in places where one knows them to abound. The hairy covering of the woolly bears, especially in the case of the fox-moth, is a most effective protection. These hairs are easily detached, and, as those who recall a recent plague in Hyde Park have occasion to remember, they cause intense irritation to the flesh with which they come in contact. The hairs act as shock-absorbers, as the motorist would say, protecting the caterpillar from injury when it falls, and they warn off practically all birds but cuckoos. The protective devices of caterpillars are deeply interesting and significant. Some species, like the larva of the goat-moth already mentioned, emit a foul odour when menaced; others, such as the caterpillar of the puss-moth, eject formic

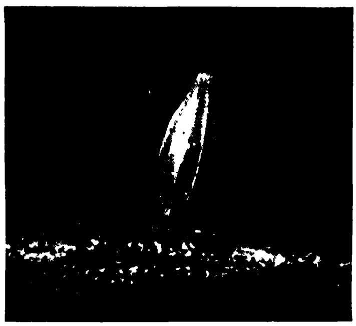
acid from an orifice on the under side of the segment immediately behind the head. At a distance of two feet, this caterpillar is able to cause temporary blindness in a victim, while so virulent is the poison that it will cause the skin to blister and peel. Here, then, in these two genera, we have the defensive scheme in miniature of the porcupine, or, better still, of that members, from each of which at will a thread-like filament is shot out. While these are at once extruded and angrily waved if the caterpillar be touched, the fore part of the body is raised, so that the whole appearance is repulsive and disconcerting in the extreme. Caterpillars of hawk-moths are armed with a horny, recurved appendage over the rear segments, and the

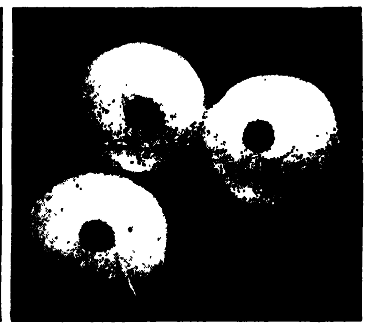

Silver-Washed Fritillary


Peach-Blossom Moth


Wall Butterfly


Yellow-Line Quaker Moth


Brimstone Butterfly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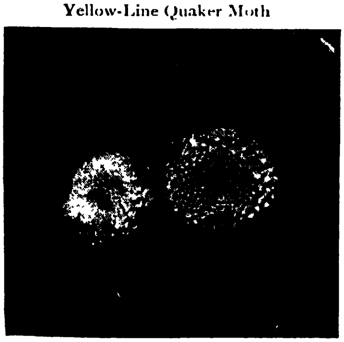
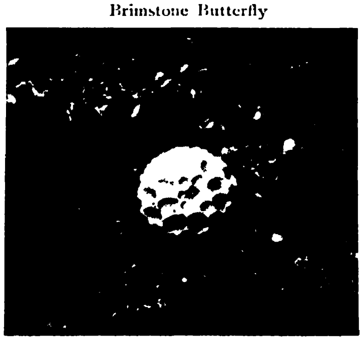
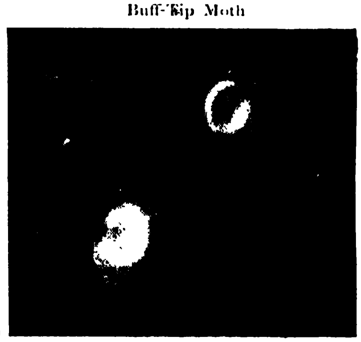

Silver-Studded Blue Butterfly


Small Copper Butterfly


Scorch-Wing Moth

THE BEAUTIES OF THE EGGS OF MOTHS AND BUTTERFLIES AS SEEN UNDER THE MICROSCOPE

hateful if handsome cactus the Opuntia microdasys, and of the spitting snake.

Another defensive device is what is not inaptly called the " terrifying attitude " of certain caterpillars. Take the caterpillars of the Dicranura genus, to which the puss and kitten moths belong. These caterpillars lack the anal claspers, or, rather, these are modified into extraordinary, tube-like threatened larva, holding fast by the legs, swings the hind part of its body with strength and rapidity. That suffices to frighten the timorous.

There is infinite gradation in the matter of protective resemblance to surroundings. Some caterpillars, when they come to rest, cannot be distinguished from twigs or thorns. The curator of the Sarawak

Museum has described a small Borneo caterpillar that is not content passively to recline amid surroundings which it has come to resemble. Living among the branches of a spiræa-like plant, which at certain seasons is covered with numerous pale green buds, the caterpillar, normally distinguished by a profusion of small, spiny processes, bites off some of the buds, and, by means of its silk, fastens them to its spines, so that it looks exactly like one of the branchlets of the plant. When these transplanted buds wither, the caterpillar discards and replaces them with fresh ones. The same variety and suggestion of discrimination occur in the choice of abode for the pupa stage.

Butterfly larvæ, content as a rule with a mere twist of silk round the middle or from one end, seem to trust more to luck than the larvæ of moths, some of which furnish themselves with extraordinarily complex little citadels. Some seek refuge in the ground, some construct tunnels of silk within the trunks of trees and between the upper and lower surface of leaves; some fashion elaborate tunnels which admit of egress but not of ingress; some content themselves with cocoons of their own silk, fortified, in the case of woolly bears, with their bristles; and others, again, like the larvæ of the Dicranura, will disintegrate even such unpromising material as wood or sandstone, agglutinise the atoms, and fashion the material into an impregnable fortress. Perhaps the most remarkable is one of the latest discoveries, that as to a well-known African moth of the genus Nyctemera, which, before turning into a chrysalis, secretes and covers itself with a mass of bubbles—a most striking defence against insect-eating animals. It is not claimed by any thinking person that caterpillars reason, nor that butterflies and moths show anything higher than instinct, but admirable M. Auguste Forel does not prove all that he attempts when he cites, as an evidence of absence of sensation in the caterpillar, the case of larvæ which, wounded at the rear, began to devour themselves, beginning behind. A captive monkey, in ill-health, eats its tail, and a sick parrot devours its own feathers, but no one suggests that these creatures are insensible to pain.

THE FURRY CATERPILLARS OF THE PALE TUSSOCK MOTH

The pupal stage of butterfly or moth may last a few weeks; it may last throughout autumn and winter; it may even extend over two years. Eggs laid in spring or early summer mature rapidly; and the caterpillars, if of the quick-developing type, will pass through all their stages within from two to three months; but a late-summer batch of eggs from the same species will result in chrysalids which winter in passivity. By such means the continuity of the species is secured. The vast majority of moths and butterflies expire with the passing of summer,

> Dying when fair things
> are fading away.

It is not true of quite all, for to some is given power to hibernate, a fact of which we have evidence upon a warm, sunny day in winter, when a butterfly, battered relic of bygone summer, creeps from hiding and leaps into the sunlight, to fall a victim, as a rule, to the first insect-eating bird that happens to be on the wing in the same locality. But, whatever the reason, the process by which the perfect insect appears is the same. At the last moult the caterpillar resigns for ever its outer skin, and lies before us, reddish-brown if it be a moth, golden if it be a butterfly—a legless mummy. In due course the chitinous case becomes impressed with the shape within. We see the legs outlined, the eyes, the coiled proboscis. Throughout the long, cold months of winter this curious image remains inert, and you must hold it in your hand, or breathe warmth upon it, to induce a little wriggle to show that life is within. The great day of deliverance comes, the shell is fractured at the top, and a butterfly, limp and damp, crawls trembling out.

That which entered the pupal stage as a loathsome, creeping thing comes forth a crowning beauty of Nature, so that one old-time enthusiast, who had patiently watched the process, declared it "the Resurrection painted before our eyes."

Four-winged, six-legged, endowed with powerful vision, here, if it be a butterfly, is the darling of the poet, like an animate fraction of the rainbow. Its wings at first are crumpled and limp, and we notice that the pattern for which we look is but dimly defined. The meaning of this has been but recently ascertained. The scales which give the butterfly its gorgeous colourings are there, but, instead of lying flat and outspread as will presently happen, they are all upstanding, so that they may occupy the least space possible within the cocoon. Soon the wings unfold, blood courses into them from the main vessels of the body. This fluid is held to be fibrin in solution, the watery medium evaporating when the work of expansion has been completed. According to Mayer, the fluid, if it lacked this fibrin, would cause the wings to become balloon-shaped bags. This is prevented by the action of the fibrin in holding the upper and lower walls together. This fibrin is derived, he states, from hypodermic cells that do not contribute to the formation of scales, but are stretched out from wall to wall of the wings.

THE LARVA AND PUPA OF A LEOPARD MOTH IN BEAN-STICKS

The life of moth or butterfly may last but a few days, a few weeks, or months; exceptionally from one season to another. Generally speaking, however, such life is brief. The butterfly, as a rule, knows but the joyous days of summer, when all the world is fair and smiling, and the air a bouquet of floral perfume. Its food is the nectar of flowers, taken by means of the suctorial proboscis. But even that may not be functional. Some of these creatures of the sunlight never eat or drink after emerging from the pupal stage. The females of some species of moth are wingless, and never leave the outside of the cocoon. The caterpillar has eaten meals enough for the butterfly. Trouvelot has shown that the larva of Polyphemus consumes in fifty-six days 86,000 times its own weight in food and moisture—*i.e.*, three-quarters of a pound of oak-leaves and half an ounce of water. The caterpillar of the privet hawk-moth will eat, during a month of larval life, food aggregating over 11,000 times the weight at which it left the shell; while the caterpillar of the goat-moth, when it enters the pupal stage, is 72,000 times as heavy as when it quitted the egg. The perfect insect, unless it be well provided for gathering the food from flowers, draws upon the reserves stored during the larval stage, as a queen-ant draws upon her reserves when setting up house and family.

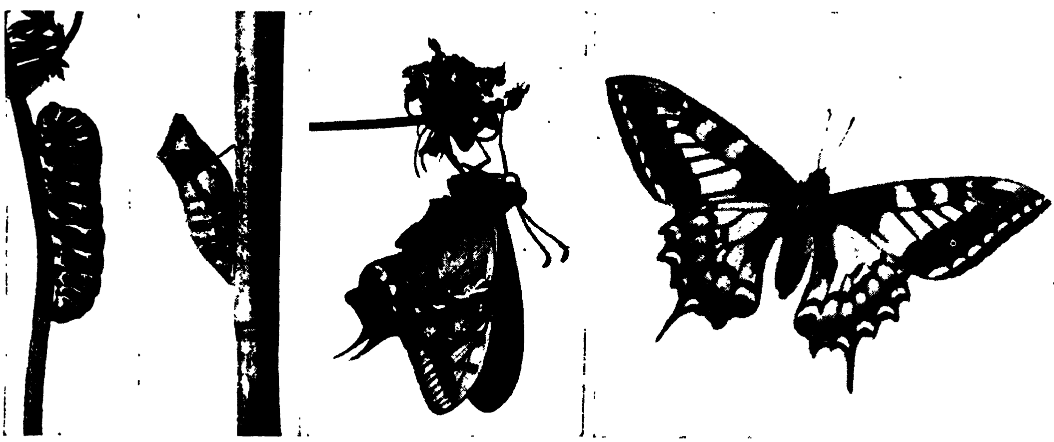
It is impossible to enter into details as to the thousandfold varieties of butterflies and moths. Perhaps a word should be said as to the dividing line between the two sections of the order. There really is no set boundary. Moths, which are regarded as night-flying insects, as of course they are in the main, have many day-flying representatives. Where, as in parts of America, bats and other enemies of night-flying insects abound, nocturnal moths are rare. There are certain distinctions to help. Each pair of the moth's wings is linked together by a unique hook-and-eye arrangement; moreover, the wings of moths are, as a rule, placed flat when the insect is at rest, whereas those of the butterfly

THE WOOD LEOPARD MOTH

are held in a vertical position. There is a difference, too, in the antennæ, those of the butterfly being club-tipped, while those of the moth are plain or "feathered." The main food of both is similar—the nectar of flowers. The white flower which gives off its sweetest scent in the evening is the banqueting hall of the moth when all the world but its immediate enemies is sleeping. Whether the moth takes carrion, we do not know, but some of our most beautiful butterflies will. The noble-looking Purple Emperor will stoop from his airy way above the tree-tops to a bait of putrid flesh upon the highway, just as the great white product of the cabbage-leaf will seek its drink in a muddy puddle.

THE DEATH'S HEAD, THE LARGEST BRITISH MOTH

The protective devices of the Lepidoptera are as striking in the perfect insect as in the larva. The case of the kallima or dead-leaf butterfly comes instantly to mind, as does the mimicry of the hornet clear-wing of the true hornet, and the startling mimicry by edible forms of others of noxious flavour. Another well-known example is to be found in the privet hawk-moth caterpillar. Modern research in this direction has carried us far ahead of ancient conceptions. Professor Poulton, indeed, produced astonishing results before the British Association a year ago, results showing that certain species of a distasteful group—the Acræinæ—mimic other species of the same group, which are themselves mimics of the chief Acræine groups. On this is based the assertion that such forms of mimicry are not related to protective design. The disputants are as yet far from proving their case; and common belief is on the side of Bates and Wallace that an edible butterfly, which mimics an inedible species, and so avoids capture by bird or animal, has a better chance of perpetuating its line than the obviously edible insect which has the great disadvantage, in the struggle for existence, of lacking such protective resemblance.



A CYCLE OF INSECT LIFE—THE CATERPILLAR, THE CHRYSALIS, AND THE PERFECT INSECT OF THE SWALLOW-TAIL BUTTERFLY

With all their equipment of dissimulation and defence, larvæ of the Lepidoptera which reach the perfect insect stage are the exceptions. From egg to pupa they are exposed to manifold dangers. Birds, insectivorous animals, and carnivorous insects eat them by myriads; countless ichneumon flies assail them, deposit their eggs within them and leave them, living larders for grubs to devour alive. And no insect has more enemies than the perfect moth or butterfly. Were this relentless war not waged

caterpillars would, in the course of a few years, overspread the entire earth and devour every green thing upon it.

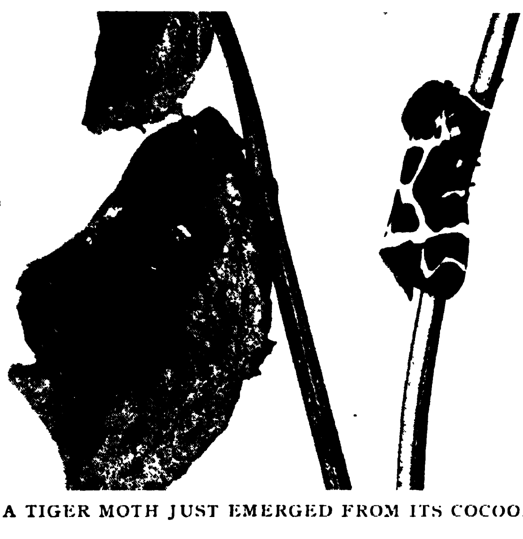
Another of our winged beauties is the dragon-fly, so matchless in its special splendour that on suddenly being confronted with one in England we cannot but fancy it some wanderer drifted from sunnier skies. Yet, as all are aware who have the good fortune to live near inland waters, these resplendent insects are common enough, though not, of course, as to all the species. The dragon-flies are divided into three families—the Libellulidæ, which yield about twenty species to Europe; the Æschnidæ, in which some of the giants occur; and the Agrionidæ, slender-bodied examples, exotic representatives of which attain a length of ten inches or more, though disproportionately slim of build. The colourings of these are brilliant as an artist's vision. Now, the larvæ of all these gems of beauty are loathsome-looking, flesh-eating creatures of the pond and lake. They have a remarkable instrument for the capture of their prey in the form of a pair of sharp pincers mounted at the extremity of a hinged or jointed arm, which can be shot out, telescope-wise, to snatch an unsuspecting fish or insect swimming within range. The larva, hatched from an egg which is laid upon or under the water, or attached to the stalk of an aquatic plant, undergoes a succession of moults in the water, and reaches the final stage of its aquatic existence at the end of ten or twelve months; and then, climbing the stem of sedge or rush, affords the spectacle of which Tennyson sang:

LARVA OF DEATH'S-HEAD MOTH

LARVA OF PUSS MOTH

LARVA OF EYED HAWK-MOTH

> Today I saw a dragon-fly
> Come from the wells where he did lie.
> An inner impulse rent the veil
> Of his old husk; from head to tail
> Came out clear plates of sapphire mail.
> He dried his wings: like gauze they grew;
> Thro' crofts and pastures wet with dew
> A living flash of light he flew.



A TIGER MOTH JUST EMERGED FROM ITS COCOON

We find beauties of another order in the luminous insects, beauties not of form but in their product. The fireflies and the glow-worms are simply misnamed beetles, not to be distinguished for any grace of outline; but, when the day is done, and all colours are put out by the darkness, then they light their wondrous lamps, the glow-worms to

illuminate bank and sward and hedgerow, the exotic fireflies to kindle their native woods with darting showers of radiance. A dance of fireflies in the sable night of a sub-tropical forest is a scene of beauty such as makes a man hold his breath in sheer delight and wonder. The stars seem to have swum from the heavens to dance a measure upon earth. In the beams of our modest little glow-worm we in this temperate land may read a newspaper, but in the tropical lands men light their path through trackless forest with fireflies pinioned to their feet, and carried aloft as torches; while native beauties imprison in their hair these winged stars of the woodland—ornaments more exquisite and more wonderful than any fashioned by the art of man.

We do not know the secret of the glow-worm and the firefly. Luminosity is not quite restricted to these; certain other click-beetles, of which the fireflies are close allies, have this special gift. Of them all we are accustomed to say that the light is phosphorescent. These lowly beetles kindle their lamps without heat and without obvious labour, and we, having attributed the effect to phosphorescence, have taken the rest as read. But have we been all this time in error? Two observers have been at work on the subject in India, and in a communication to "Nature" they reach a startling conclusion. Upon putting a firefly of the genus Luciola into a glass tube, they were struck by the resemblance of the green fluorescence of the light to that of the Crookes tube. Could this light, they asked themselves, be akin to the X-rays? They tried a number of experiments, and found that the light of the firefly penetrates wood, leather, flesh, and black paper, and imprints itself upon a photographic plate fixed beyond these obstacles. The insect light was found to approach lamplight in the intensity of its effect on the photographic plate, even when the different media opaque to ordinary light were interposed between the two. The light cannot, therefore, be taken as phosphorescent, say our investigators. "It may be premature to conclude that some of the rays emitted by the insect are X-rays, but it may be safely asserted that these rays are at least similar to X-rays and ultra-violet light in so far as they render certain opaque media transparent, and are intercepted by glass."

THE BEAUTIFUL DRAGON-FLY

How the theory would have interested the late Professor Langley, of Washington! He passed many a fascinating hour in studying that moon of Nature's nightlights the great Cuban firefly (Papophorus noctilucus), seeking its secret by the aid of the refined measurements of the bolometer—which records a change in temperature of one-millionth of a degree—and by the aid of the spectroscope. He could but report: "The insect-spectrum is lacking in rays of red luminosity and presumably in the infra-red rays, usually of relatively great heat, so that it seems possible that we have here light without heat." Thus the scientist.

Superlative beauty of radiance without heat results from the emanations of these lowly insects, a mystery as challenging as the discharges from the cells of the electric-fish. Light without heat from an insect—and the production of artificial light by man's contrivance involves the expenditure of from fifty to a hundred times as much wasteful and injurious heat as the illumination gained! If man by mechanism could imitate their light production, we should deem it a miracle. The firefly and the glow-worm are to us merely scintillating points of beauty in night's dark canopy. But what inscrutable efficiency they represent!

A SURVEY OF HYPNOTISM

The Different Levels of the Hypnotic State, and How They May be Used and Abused

STRANGE EFFECTS OF SUSCEPTIBILITY

WHAT we have already learnt of the subconscious mind will prepare us to study the facts of hypnotism with somewhat less disdain than the medical profession, as a whole, in this country has hitherto permitted itself. Here is a dominion of fact, not only instructive, but also of high practical value, which has until lately either been neglected altogether or else employed in objectionable ways. The medical schools have ignored it, notwithstanding the quality and authority of the Continental literature on the subject, which we owe to such men as Charcot and Liébault and Forel. In this country hypnotism, or, rather, the pretence of hypnotism, has almost been confined to the music-hall stage.

The first statement to make about hypnotism is that it is much too serious and important a matter for public exhibition, that public pretence of it is obviously objectionable, and that actual hypnotic exhibitions in public would be worse, as being extremely likely to involve serious injury, sooner or later, to the mind and physique of the hypnotised person. All such exhibitions, actual or pretended, should be banned alike by law and public opinion.

The only person who can benefit by such exhibitions is the real or pretended hypnotist. If he had exceptional powers, peculiar to himself, and capable of performing great services for others, there would be a very urgent argument in favour of letting him exhibit them, however objectionable his success might be to more regular practitioners. But the first scientific proposition which we shall here make about the hypnotic process is that the hypnotist does not play the part which the public and his subjects suppose, and which, no doubt, many hypnotists in the past themselves supposed. The accepted idea is that the hypnotist hypnotises his subject by means of some force resident in himself, and presumably alloted to him in rare and mystic measure. We cannot better understand this question than by briefly looking at the history of it.

We may begin with the celebrated performer Anton Mesmer, from whose name the word "mesmerism," an old name for hypnotism, was derived. He asserted, and very probably believed, that his results were due to a mesmeric force which emanated from himself; and it needs little imagination to suppose that such a force would be electrical or magnetic in nature, or allied to those mysterious and invisible modes of energy, about which we think we know a little. There is, however, not only no evidence that any "mesmeric" force of the kind exists, but also abundant evidence that no such force need be imagined for the production of the hypnotic effect.

Suppose, then, that we totally reject all ideas of any kind of *physical* force, or mode of energy, that passes betwen the hypnotist and his subject. There is an alternative. We may argue that the hypnotist produces his effect by a *psychical force*; and in order to confuse ourselves and our subsequent thinking as completely as possible we may call this psychical force, which the hypnotist employs, by the name of "will-power." It is argued, then, that the hypnotist indeed employs no physical means, visible or invisible, but he has an invincible will, to which all must yield. He imposes this will upon his subjects in the chair, and the deed is done. The successful hypnotist, on this view, will be, like the poet, born, not made. Only here and there, at rare intervals, will a man arise who has in him the "psychic force" of an indomitable will. Others may try to imitate him, but must fail.

Now, just as we totally deny the existence of the "mesmeric fluid" about which our

grandparents used to talk, so we deny the existence of " will-power " in the sense of some unthinkable psychic force that passes from the hypnotist to his subject. There is no reason to believe in the existence of any such thing. The will of the hypnotist has nothing to do with the matter, though the will of his subject has much. The manifestations of hypnotism are mysterious and wonderful enough, but we have no reason to suppose that the hypnotist has access to the *psyche* of his subject by any other than the ordinary routes of sensation. The hypnotist himself may have a strong will or a weak will. No hypnotist hypnotises his patient, in the sense in which the public, to say nothing of many who should know better, use the word. The old idea, fostered by the less reputable pioneers, who had their own advantage to consider, was that the hypnotist produced his results by means of the irresistible concentration of his indomitable will upon the helpless personality of his patient. The strong man's eyes glared, his hands made mystic passes, the " cold perspiration bespangled his brow," testifying to the tremendous effort of the will within, and the subject surrendered.

Sir Francis Galton's Interesting Experiment in the Early Study of Hypnotism

This is all nonsense, though we shall readily understand the facts which lent it the air of truth. The hypnotist need not even be thinking of what he is doing. The late Sir Francis Galton, a man of keenly critical and experimental temper, tells us, in his " Memories of My Life," that, many decades ago, when studying medicine—which he afterwards abandoned or shortly thereafter, he made many experiments in hypnotism, with much success, as those who knew his personality in old age may well believe. The current doctrine was that the would-be hypnotist must concentrate all his attention and "force of will" upon his task if he would succeed. Young Galton wondered ; he was not so sure ; and so he set himself to compare results, in two sets of cases, concentrating his attention according to rule in the first, and deliberately thinking of something else and paying no attention at all, while keeping up the necessary appearances, in the second. He found absolutely nothing to choose between his success in the two sets of cases. Modern hypnotists sometimes nowadays do not even use their personal presence at all. There is a kind of revolving clock, said to have been invented by Liébault, which makes a kind of " soothing," whirring noise, and which the hypnotist may set going in the room where his patient is, and when he returns, a quarter of an hour later, the patient may be in the hypnotic state.

The reader who recalls what we observed when studying suggestion in Chapter 30 of POPULAR SCIENCE has the key to the facts. Suggestion, as modern psychology terms it, is at the root of them. There is no " mesmeric fluid," no " psychic emanation " from the hypnotist, there is no " willpower " acting from him upon his subject. The hypnotic state is induced by suggestion.

The Part Played by the Personality of the Hypnotist

No doubt you may hypnotise a hen by means of a chalk line on the floor, which suggests to her that there is nowhere else to walk than upon it ; and upon that line alone she will walk till further notice. Suggestion similarly hypnotises most of us to walk upon the chalk lines made by our predecessors and fellows ; we have to do as they did, just as one sheep must follow another through a hedge ; like the hen or the sheep, we can really imagine no other course. Anything may suggest to the suggestible person ; and the beginning and essence of the whole of the phenomena is not any mesmeric fluid, any force of will, but the fact of the human *psyche*, shared with the *psyche* of many lower animals, which we call suggestibility.

No doubt it was true that the personality of the hypnotist counted, and no doubt we, in their day, should have framed no better hypothesis to account for its power than our predecessors did. Their view was reasonable enough, in the absence of evidence to show that, so long as suggestion occurred, the agent through which it occurred might be anything the personality of the hypnotist, the spirit of the mob, a chalk line upon the floor, or anything else. But now we know, beyond dispute, that the personality of the hypnotist only plays the part which we readily understand when we recall what we have seen as to " prestige suggestion."

The Power of a Man to Hypnotise Himself at Any Time

When a willing subject is hypnotised, the subject himself is the active agent. He suggests to himself the idea that, in the particular circumstances, it will be possible to go to " sleep," and he does so accordingly. There is quite enough left for posterity to explain, but at least we have made some progress ; the phenomena of hypnotism are not assumed and fraudulent,

but do occur; and they do not occur by the action of any psychical agency on the part of the hypnotist. In fact, we observe, the hypnotist may be dispensed with—rather an effective piece of fact against the older theories of the subject.

Many people have learnt to hypnotise themselves, and can use their powers to some purpose, especially for inducing sleep. Such cases as that of Napoleon, who is said to have been able to sleep at any time and in any circumstances if he chose, probably involve the equivalent of self-hypnotism or self-suggestion. Probably almost anyone who set about it in the right way, and had patience, could learn to practise self-suggestion to this extent.

The Hypnotic State Not Induced by Influence Outside the Patient

The reader must observe that we have not denied the possibility of psychical influences, perhaps from unknown sources, being able to exert their action upon the hypnotic subject. That may or may not be so. We have only asserted that the hypnotic state is not *induced*, as former generations believed, by any psychical influence from outside the patient. Even where the potent aspect and reputation of the hypnotist, and also his technique, seem most strongly to argue the action of some psychical force upon the patient, the true explanation is that the patient has practised self-suggestion, and that the suggestion—of passing into the hypnotic state—has been made effective, and has, so to say, convinced the self, by using the hypnotist as an argument. If the subject does not believe in the hypnotist, then his aspect and his technique are no argument, and the self-suggestion will not occur.

The Absurd Devices of the Music-Hall Quack Who Plays with Hypnotism

Thus we need spend little time upon the manner of inducing the hypnotic state. A Mesmer or a music-hall quack may practise all manner of "passes," mystic formulæ, accompaniments of darkness or flashing lights, or weird sounds, or what not. We realise now that these are not at all essential, though they may serve for the patient or subject whom they suit. A modern, responsible, and honourable physician, who practises hypnotism, will employ no such devices. The subject sits opposite him, in a comfortable chair, not facing the light, and is simply asked to collaborate with the hypnotist, and to try to accept the suggestions which he will make. The initial suggestion is simply that the patient shall go to "sleep." We use inverted commas, because there are, of course, certain very essential differences, about to be discussed, between the hypnotic state and sleep. The operator assures the subject that in a few minutes he will find himself becoming sleepy, that he will feel the eyelids dropping, the limbs relaxing, and that he will then go to sleep. The subject is asked to believe these assertions, and to try to realise them. The hypnotist may gently stroke the forehead, or the closing eyelids, and meanwhile whispers "Go to sleep," "Now you're feeling sleepy," and so forth. This description of the technique, to dignify anything so simple by the name, may be varied in different cases, but essentially there is nothing more in it than this. The success or failure of the experiment depends essentially on the subject. In so far as it depends upon the operator, it does so in the fashion simply indicated by the fact that, if someone else were to represent himself to be the reputed operator, he would have similar success.

The Varying Susceptibility of Different People Under the Hypnotist

In the hypnotic state, as under the action of nitrous oxide, there is always the possibility of delusions on the part of the subject. It is an absolute rule, which should never be broken in any circumstances, that the practice of hypnotism should never be conducted without the presence of a third person, for the safety both of the operator and the subject.

Very brief experience will suffice to prove to any operator, whatever his prestige, that different people vary very widely in their susceptibility to his technique, or in their suggestibility. He will have no success with patients who do not want to come, who have been bullied or cajoled into visiting him, and either have no belief in his powers, or fear him, or are determined that they will not be hypnotised. Knowing what the process essentially consists in, we need not be surprised at that. He will, in general, be more successful with women than with men, and with the young than with the old. Hysterical persons are, as a rule, readily and deeply hypnotised.

Sometimes the patient is refractory to the process, though willing. After many attempts, at last the hypnotic state may be induced. Thereafter there will be little difficulty, or none, in reinducing it. The proposition knows no exception that the process of being hypnotised is exactly proportional, other things being equal, to

the suggestibility of the patient. This has a native, natural basis, which is, in degree, common to us all, though it varies widely in different people, races, ages, sexes, as we have hinted. But it also depends in part upon the experience of the individual. Thus the patient who has once been hypnotised becomes, as a rule, far more suggestible ever thereafter. It is almost as if the subconscious reason, if there were such a thing, argued that what has once happened may happen again. Dr. Milne Bramwell records many cases where he has failed, after long-repeated trial, to induce the hypnotic state, but, having succeeded once, he had no further difficulty.

What is the Real Psychical Condition of the Hypnotic Subject?

What, then, exactly is the hypnotic state? Our answer may content itself with merely noting what may be observed when we look at the hypnotic subject; or we may attempt to define, in psychological terms, the psychical state of the hypnotic subject. The first kind of answer is perhaps a millionfold the easier. Students of the subject vary somewhat in their definition of the various levels of the hypnotic state, and some will describe five or six, perhaps, when others only recognise three such levels. A very trustworthy authority, of high rank and wide experience, is Dr. Lloyd Tuckey, whose text-book on hypnotism has passed through many editions, and may be commended to the reader. He agrees with various other writers in recognising four principal depths of the hypnotic state.

The Frenchmen are the great authorities on this subject, and have given apt and expressive names, as their custom is, to the various conditions they have recognised.

Four States of Hypnotism which May Pass Into One Another

Here we may content ourselves with describing, first, the state of slight sleepiness, with slightly increased suggestibility; second, the state of definite hypnosis, in which the subject will readily receive suggestions of almost any kind; third, the state of deep hypnosis, in which insensibility to pain is as entirely abolished as in drug anæsthesia, and in which surgical operations can therefore be performed; and fourth, the deepest state of all, which is the same as that of the noctambulist, or sleep-walker.

This classification is not to be too rigidly accepted. There are no abrupt breaks in Nature; all transitional stages occur between a liquid and a gas, though we usually fail to notice them, and between the ordinary waking and the ordinary sleeping state. There are many levels within ordinary sleep, and many degrees of awakeness. Such a division of the hypnotic state into levels, with categorical definitions, may be misleading unless we note that the levels may and do pass rapidly or slowly into one another, and that, for instance, your subject, who was at one moment scarcely sleepy, may at the next be in the deepest state of automatic behaviour, after the fashion of noctambulism. Further, while one subject will pass rapidly into the deepest state, another may never, by any device, be got further than number two, or even number one. Nevertheless, such a classification as we have given is fairly representative of the facts, and has very evident uses. We know, with some accuracy, what are the possibilities, the advantages, and the dangers of any of these states, and we may deal with them accordingly.

The Deep State of Hypnotism which May Seriously Impair the Patient's Mind

The fourth, or deepest state, may briefly be dealt with first, for the sufficient reason that it is to be altogether avoided. It has no uses or advantages for any of the therapeutic purposes which we shall shortly consider. Nay, it has definitely untherapeutic properties of its own. The frequent induction of this psychical condition may prove to be very injurious to the patient's mind. No responsible hypnotist would ever deliberately induce this state in any patient, or any subject upon whom he was experimenting; and if this state were to occur, the hypnotist would at once rouse his patient, and take care not to let it occur again. The hypnotist can always rouse his patient by telling him to waken; if there is ever an exception to the rule that this process involves no difficulty, and is practically instantaneous, it is in cases where the deepest hypnotic state has occurred. Sometimes, then, there may be some difficulty in arousing the patient.

The sleep-walking adult or child should be well looked after, and protected from risk. Not only so, but efforts should be made to get the patient out of the habit, which is not a good one. Doubtless, in most instances it may lead, or seem to lead, to no harm, but we know too much about it now to look upon it with equanimity or jocularity. Those who are in this state are not very far removed from an unquestionably morbid and injurious condition of the mind which is known as catalepsy. Here the self, the personal will, the autonomy.

of the patient have completely surrendered their powers. The patient has become an automaton.

In the so-called "waxen catalepsy," the limbs may be set in any position, and there they will remain until sheer muscular exhaustion compels them to drop. The patient is like wax under the modeller's fingers. One eyelid may be opened and the other closed in the morning, and so they will be found when the subject is visited again in the evening. It may readily be imagined that catalepsy, whether lasting for months or a few hours, can scarcely be desirable for the health of the mind. Cataleptic seizures too often hasten the mental degradation witnessed in lunatic asylums. We do not here assert that occasional sleep-walking is to be regarded with unreasonable alarm—it is too commonly devoid of serious results for that—but we do assert that the condition is not normal, but morbid, though perhaps only slightly so; that it should be dealt with by a suitable regimen during the day, and that no responsible hypnotist can ever willingly induce this extreme state of hypnotism in his patients, or the subjects of his experiments.

The Hypnotism of the Sleep-Walker and the Hypnotism of the Day-Dreamer

Those who may have to deal with a sleep-walker should know that the phenomenon, though remarkable, is not occult or diabolical, or dangerous to anyone but the sleep-walker himself. It is, of course, well known that the absence of fear from the mind in the noctambulic state permits of strange feats, walking along parapets, and so forth, which would otherwise be impossible. To "waken" the noctambulist by shouting at such moments is, of course, to court disaster. When he or she is accessible, the simple suggestion to go back to bed will be readily and certainly complied with. Then let the ordinary state of waking consciousness be restored in physical safety there, and without alarm or shock to the subject's mind.

So much for the deepest level of the hypnotic state. For convenience, let us now deal with the slightest degree of hypnotism, which many casual observers would perhaps pass unnoticed. Patients who consult physicians practising hypnotism, for relief from neuralgia or insomnia or nervousness, or what not, may frequently find it impossible ever to pass into a deeper state than this of perhaps very slight drowsiness, with the ears "attuned" and sensitive to just one sound, the voice of the hypnotist, and the mind rather more ready than normally to credit what he says.

Suggestible people no doubt pass into this state more frequently than is sometimes supposed. The ardent lover of Nature or of music may sometimes find himself in a state of "day-dreaming," or something like it, which is practically the same as we are here describing. Many a girl has disastrously yielded to her "lover's" suggestions when in this state. It is probably induced very largely in certain parts of the world at religious "revivals."

The Efficiency of Suggestions of Healing in Slight Cases

The structures of the mind which are very closely concerned with the more emotional forms of religion, and those concerned with the interests of sex, have been known in all ages to be allied. Under this condition of slightly heightened suggestibility and irresponsibility, people follow one another's example, and yield to the entreaties of a "revivalist," but their self-control is weakened in other ways.

In the medical practice of hypnotism, this shallowest level of hypnosis may often be very useful. The hypnotist would much prefer to induce a deeper "sleep," but often he cannot, especially in the more rational type of patient. Nevertheless, if only this light hypnosis can be induced, "suggestions of healing," or "therapeutic suggestions," as they are called, may often be efficient. This will be so especially in slight cases of distress, such as insomnia or neuralgia. Too often, however, the suggestions made when the subject is in this state are not effective, or retain their effect for only a very short period of time.

When a Man May be Physically Asleep and Mentally Awake

For therapeutic purposes, the second stage, according to the definitions we have employed here, is the valuable one. The patient is now really "hypnotised." The pulse and respiration are probably calm and rather slow, as in sleep. *Hypnos* is Greek for "sleep," and we call a drug which induces sleep a hypnotic. But hypnosis is not sleep. In many physical particulars the patient may be asleep, but he does not let his head nod or his jaw drop. Further, parts of his mind which are asleep in true sleep are not asleep now. He can hear and see, as Trilby could hear the notes which she had to sing in Du Maurier's clever novel. But the patient's reason and will *are* asleep. Hence the patient will accept suggestions, but not all suggestions. The hypnotised

hen will only walk along the chalk line that has hypnotised her; no other lines are any good to her. So here the subject will listen to the suggestions of the person who has hypnotised him or her, but not to other people's. The spectator may try to "waken" the subject, by any violent means, but will fail. If the operator merely whispers "Now waken," the subject will open the eyes, look round, and recover the normal consciousness at once. The spectator may give orders or make suggestions; that the subject is no more suggestible than usual to any source of suggestion but one. From that one source alone, however, almost anything will be accepted. The subject will blow the nose, sing a song—usually not at all like Du Maurier's description of Trilby's singing—get up and do any absurd thing. It looks, certainly, as if the will of the operator had established itself in the mind of the patient, and, with important reservations, as we have seen, that is so. To be more accurate, we may say that the

THE CELEBRATED SLEEP-WALKING SCENE IN SHAKESPEARE'S "MACBETH," AS PLAYED BY MRS. SIDDONS AT DRURY LANE—FROM THE PAINTING BY MR. TALBOT HUGHES

they will be ignored. The subject has therefore not surrendered all will and all reason. There is what, the powers of language failing us, we have called a subconscious reason, and even a subconscious will, at work.

Provided, as we saw in an earlier chapter, that suggestions be not made which are contrary to the whole character and moral feeling of the patient—and which will be rejected with signs of disgust or horror—the subject will now do whatever the operator suggests. In other words, the most characteristic and important descriptive fact of the hypnotic state is heightened by specific suggestibility. For we have seen will of the operator has established itself in the *subconscious* mind of the patient; and the consequences will be according to the natural properties of that subconscious mind. They now begin to be revealed.

For the operator's suggestions do not merely apply to the patient's behaviour while he or she is in the hypnotic state. On the contrary, the operator may say that, in eleven hundred or two minutes from that moment, the subject, whatever he or she may be doing, is to go to the dining-room and put the fireirons under the table, or close the shutters, or empty the decanter out of the window—and it will be done. On "waking," the subject has no

recollection of the order; the ordinary waking mind has not heard it, but somewhere, somehow, the necessary calculation will be made; and at the appointed moment the subject will find himself, to his own great surprise, leaving his occupation and performing this absurd act, for no reason which he knows. The subconscious mind is obeying orders, and giving orders accordingly.

We might multiply indefinitely the authentic accounts of what suggestions received in the hypnotic state will cause a subject to do. The scientific fact is simply that this heightened suggestibility occurs, and that its consequences *outlast* the hypnotic state, and show themselves even when the subject has returned to the more moderate suggestibility of his ordinary life. Like the man of mature years who, in a crisis, obeys suggestions made to him when he was at his mother's knee, the subject finds himself obeying orders of which, in this case, "*he*" has no recollection whatever. He could truly swear that he had never heard such a thing, to say nothing of remembering, but the subconscious mind heard and remembers, and orders accordingly.

The Value of Hypnotism in the Treatment of Illness

It is evident that here are therapeutic opportunities. Let us try to relieve cases of illness, distress, disordered action of any kind, which may perhaps have their origin in the subconscious mind, as, failing deeper knowledge, we can but call it. We can surmise, for instance, from our own experience in strange bedrooms, and so forth, that the subconscious mind—not the personal will, but a kind of will beneath it, which our will cannot control—plays a part in the induction of sleep.

Again, we are aware that there is some nervous control of the action of the bowel, though this, like sleep, is not under voluntary control. Might it not be that cases of insomnia, or of constipation, could be cured outright without drugs or difficulty if the patient could be hypnotised and have suitable suggestions made to the subconscious mind when the ordinary reason and will were in abeyance? If the suggestion be made when these are not in abeyance, they will obstruct it. The reason says, from its experience, that this is nonsense—one cannot go to sleep at such and such an hour because someone says so. But if the will and the reason can be, so to say, "short-circuited" and the suggestions, though irrational, can thus be accepted by the subconscious mind, they may be effective.

In such cases, the results are often wholly admirable. The patient has had the suggestion made that at ten o'clock in the evening he will go to sleep, and will remain asleep, without dreams, for eight hours, and awaken, refreshed and ready for hot milk, at six; and he simply does so, though all manner of devices have utterly failed to give him such sleep for months before. Exactly similar means may suffice to cure constipation; the patient is told that the action of the bowel will be as regular as clockwork thereafter, and it is.

The People who Can be Hypnotised and Those who can Not

The principle may be laid down that whatever morbid conditions of the body or of the mind are under the control of the subconscious mind may be controlled by therapeutic suggestions received during the hypnotic state. A certain number of people cannot be hypnotised, and these possibilities are therefore not for them. Others can be hypnotised, perhaps by one operator, but not by another; and others can be hypnotised by anybody—that is to say, they are so readily suggestible that, whenever the conditions favour at all, they will accept the suggestion of passing into the hypnotic state.

For those persons who can be hypnotised to some definite degree, and who are doubtless the very large majority of the inhabitants of Great Britain, and a still larger proportion of the inhabitants of France or Italy, this measure offers, in capable and responsible hands, advantages which no other form of therapeutics can command. Practitioners who are too sanguine and too little critical may be willing to employ hypnotic suggestion in cases where it cannot reasonably be expected to succeed—say, in cases of lupus, or tuberculosis of the skin, a malady which has nothing to do with the subconscious mind. But the right kind of cases have yielded extremely good results.

The Continental Doctor who Would Hypnotise a Patient to Give Him Sleep

On the Continent, hypnotism is now largely employed for therapeutic purposes. We are told, for instance, that sleep is induced by its means in cases of pneumonia, where sleep is so important, and where the use of drugs in order to obtain it is so undesirable. To the best of the writer's knowledge, hypnotism has never yet been employed for such a purpose in this country. In all forms of insomnia, hypnotism may be extremely useful. It has won similar success in nervous constipation, as we can readily

understand, and in all kinds of nervous pains—neuralgias, tics, and aches. In the various forms of hysteria, hypnotic suggestion may prove very useful; and the hysterical patient is usually an easy hypnotic subject, though it is said that in such patients the suggestions require to be repeated, losing their force after a time much more readily than in other patients.

The Opportunity of the Hypnotist to Strengthen a Patient's Will

In the discussion of hysteria, now many years ago, the late Sir James Paget remarked that, while the patient says "I cannot," and her friends say "She will not," the truth is that she *cannot will*. In the cases of hysterical paralysis which are so familiar to doctors, this dictum is well illustrated. The patient's bones, joints, and nerves are all in order, but she cannot walk, or can only whisper, because she *cannot will* the activity of the muscles of her legs or of her larynx. Here is the opportunity for hypnotism. In typical hypnosis, as we have seen, the patient's conscious will and reason are "short-circuited," and the suggestions of the hypnotist have direct access to the subconscious mind of the patient. He tells her that she is to walk—for she can walk perfectly well—and she does so. He tells her, further, that on "waking" she will be able to walk, and so she does. We may interpret this in various ways, but the most reasonable seems to be that which argues for the reinforcement of the subconscious will of the patient by means of the hypnotic suggestions. When we say the patient "cannot will," we do not mean that she "herself" does not will to walk. She does; she is more willing to walk than we are that she should, poor thing. She does will, but she does not will effectively.

The Immense Value of Hypnotism in Curing Bad Habits

We realise now how many levels the mind has. The highest level here, the level of conscious will, wills as it should. But what we have here ventured to call the subconscious will, the chief servant and executor of the conscious will, is out of order. To say what is the matter with it would be to solve the problem of hysteria. But the suggestions of the hypnotist come to the rescue; and thereafter the conscious will of the patient becomes effective.

There are many other cases in which hypnotism succeeds; and if we remember our theory of its action we shall readily understand why it may succeed in these cases, and must always be entirely futile in others. In many cases of bad habits, therapeutic suggestions received in the hypnotic state may effect a cure when everything else has failed. Perhaps many cases of hysteria are really a kind of bad habit of the subconscious mind, and thus come almost into this category. Bad habits in childhood, such as incurable biting of the nails, and habits much more inconvenient and injurious, may be cured by hypnotic suggestion. In adults, inebriety and all forms of drug addiction may in many instances be cured by hypnotic suggestion; and the serious student of inebriety, who knows of how many and various underlying conditions this may be the mere symptom, will be able to predict the type of case—the weak-willed, well-meaning, neurotic drinker—in which this method will be successful, *because* it reinforces the too slack powers of the subconscious mind. But little can be hoped from hypnotism in the case of the defective-minded or the vicious drinker.

Why Hypnotism is More Widely Understood on the Continent than in This Country

On the Continent the study of hypnotism is much more advanced than in this country, but perhaps not wholly on account of the traditional insular conservatism and concrete-mindedness of the medical profession here. We say "not wholly," because these very characteristics of the medical profession are characteristics of the race from which it and its patients are drawn, and this race does not furnish the best hypnotic subjects.

For them we must go to the more excitable, hysterical, suggestible peoples of France and Southern Europe, as doubtless also to certain quarters of our own islands, such as Ireland and Wales. It is among such peoples that hypnotism will show its most marked phenomena, and therefore among them that it can be most useful in medicine. The deeper levels of the hypnotic state can be more readily induced in the Southern European subject; and hence we find, as we might expect, that the records of the medical, or rather surgical, use of the third level (with cutaneous anæsthesia) in place of the use of chloroform or ether, are derived entirely from the Continent.

The surgeons in this country have had no recourse to the use of hypnotic anæsthesia, and they are probably quite right on the whole. At the same time, every surgeon is familiar with cases where an operation should be performed, but the giving of any anæsthetic is too risky, owing to the state of the patient's heart; and in such cases hypnotic anæsthesia might be used.

Cases of the relief of pain, and of the induction of anæsthesia for surgical purposes, by the use of certain kinds of light, especially blue light, if memory serves, are often recorded in the newspapers as having occurred upon the Continent; and the English reader wonders why, since chloroform and ether are not free from risk and discomfort, anæsthesia cannot be comfortably induced on this side of the Channel by merely exposing the patient to a "soft blue light." No surgeon exists who would not be glad to use blue light instead of chloroform if he could. But the fact is that the blue light, or whatever it is, merely serves as the suggestive agent, and the patient about whom we read has been hypnotised into anæsthesia. This is very excellent, when the patient is such that he or she *can* be suggested into hypnotic anæsthesia by the simple magic of a blue or any other coloured light. But in this country such patients are not common enough, though they doubtless exist in considerable numbers, and the surgeon accordingly cannot count upon the suggestibility of his patient.

The Palmy Days of Hypnotism that are Passing Away

Besides, the more we know about suggestion of any kind, the less suggestible we become. Hosts of readers of POPULAR SCIENCE, who happen not to have studied this subject before, were suggestible enough to be hypnotised before reading this article, but will never be hypnotised now. These facts have to be remembered when we incline, as some have inclined, to the view that the practice of therapeutic suggestion has an unlimited future in front of it. No doubt its possibilities are only beginning to be realised, especially in this country; but if we analyse the facts upon which they depend we shall see that the printing-press and the school, and the spread of scientific ideas, are their enemy. The palmy days of hypnotic suggestion would have been—or were those before Gutenberg and Caxton, but in those days the operators rather than their subjects were advantaged.

The famous French neurologist Charcot has left us the most remarkable descriptions of the phenomena he was able to elicit when first he began to study the possibilities of hypnotism in Paris. He would get a whole wardful of ignorant and superstitious peasant women, ready to believe anything, and then could control the behaviour of one after another, in any fashion he pleased, by a mere word. Where he directed, they would feel agonising pain, or be relieved of it; there would be only one effective conscious will in the room, and the rest of its occupants would be his marionettes. We may take leave to doubt whether Charcot would have been quite so successful, say, in Leeds or Aberdeen. So much for the chief phenomena, and the therapeutic possibilities, of the various levels of the hypnotic state, as well as we can define them.

The Wise Doctor's Patient who Saves Himself by Believing

But let the reader beware of supposing, against our frequent warnings in these pages, that there is any absolute line between the ordinary waking state and the heightened suggestibility of the hypnotic state, any more than there is any absolute line between waking and sleeping. Short even of the shallowest level of the hypnotic state, with its slight sleepiness and slightly heightened suggestibility, there is the measure of recipient expectancy which any or all of us may have, in varying measure, at any time. This is what doctors hint at when they talk of a "good bedside manner;" this is why the great consultant from the metropolis cures the patient whom the rural practitioner knows far more about, and has failed to relieve, and cures him by the continuance of the same treatment. The patient believes, his unconscious mind has had suitable suggestions effectively made to it, and he gets well. This is why water-and-salt from a hypodermic syringe, being called morphia, have sent many a patient to sleep, and why many attacks of indigestion and lack of appetite and what not have been relieved by a prescription containing the words "Sacch: Ust:," though "burnt sugar" would not have done so well.

The Difference Between the Wise Man and the Foolish

This also is why the great doctor, the perfect nurse, the friend in need, the leader of men, the persuasive teacher, the reformer, the pioneer, is born, and not made, and why science and skill, without the magic of suggestion, can never avail against that magic alone. However wide-awake we may be, we are at some level or other of the hypnotic state; and the only difference, perhaps, between the wise and the foolish, the rare birds called men and the many-headed mob, is that the wise men are wise enough to know, and the others do not know, which are the suggestions, and who are the suggesters, living and "dead," worth listening to.

AN OLD AGE "LOVELY AS A LAPLAND NIGHT"

THE PAINTING ENTITLED "CHARITY," BY MR. A. S. COPE, A.R.A.

THE GENTLE PATH TO AGE

Cardinal Rules for the Guidance of Men and Women Past Life's Most Perilous Periods

THE MAINTENANCE OF MENTAL YOUTH

If man is primarily a mind, the physical aspects of growing old cannot comprise all that we have to learn. The happy few, as we occasionally encounter them, have the secret of perpetual youth, and the secret is contained in no flask or vessel, no powder papers, or injection syringe. Youth is a state of the soul, and the elixir of youth must itself be spiritual.

Too little is yet known about natural old age, just as too little is yet known about normal death; the cases are so rare. But we may certainly deny that, after the period of adolescence, years are any real criterion of age. It is true for the tree that its very structure measures the yearly revolution of our planet round the sun, but *we* neither lose nor lay a layer of our persons in correspondence with this revolution. So far as the body is concerned, the arteries are the best criterion of age, and their state is certainly not dependent on the passage of time as such. A man is as old as he feels. The woman who decides to have no birthdays is perfectly warranted in so doing as long as her mind remains young; but if her mind remains young, she will not worry about her birthdays in any case. Nothing will arrest senile changes in the skin, but it is possible to prevent senile changes in the soul.

To some extent the nature of normal old age in man may be inferred from our observation of the lower animals; but most of the animals we observe are domesticated, over-fed, and under-exercised, so that there is a source of fallacy there, too. Most of what we call old age in man is a morbid deterioration, the beginnings of which may be well marked in the thirties, or, on the other hand, may scarcely appear in the eighties. So far as the mind is concerned, the difference between ten and twenty, or even between twenty and thirty, is necessary and unmistakable, but it by no means follows that any substantial difference between thirty and sixty is necessary. We can all observe or quote notable instances to the contrary.

As compared with the child, the adult is less capable of making nervous acquirements. This power of making acquirements, or of learning by experience and practice, is an expression of adaptation. Every living organ, or function, in losing its power of adaptation is on the high-road towards death. All such power gone, there is either absolute death or else death in life. Let us beware, then, of the loss of power to change our minds. The man who can no longer change his mind will never change anything outside it; he will never be a cause again, except as an obstacle is a cause. The extraordinary success of the recent play "Milestones" depends upon its pathetic truth to this great mark of advancing years. The boy who believed in iron ships as against wood becomes the man who, on hearing of the talk about steel ships, says it is only talk. He can learn, receive, adapt himself no longer.

The rate of change in the modern world is so enormously accelerated, however, that it is daily becoming easier for us to retain our mental adaptability. We live in an atmosphere of change and development. It is useless to deny the existence of our senses. Lord Kelvin, in his old age, at the last pooh-poohed the motor-car, the aeroplane, the discovery of radio-activity, and the electron; but, had he lived five years longer, he would have had to yield to the accomplished facts. The importance of mental atmosphere cannot be denied; we see it when we compare the average townsman with the average countryman; but the spread of the Press is doing much for the countryman in this respect. The conclusion is that mental movement, alertness, development around us do directly exercise the

mind so that it keeps in condition. The parallel to the practising which the violinist or the pianist or cricketer finds necessary is close.

The wise man, therefore, who wishes to remain essentially young, will carefully ensure such mental surroundings as involve a mental gymnastic and constant mental refreshment. If he has his choice, this requirement will be complied with alike in work and play. First, then, the elderly require the company of their juniors. The young, children and adolescents, beat us in memory, in curiosity, in agility of mind, in receptiveness, and in sheer *joie de vivre.* But by the laws of suggestion and imitation they can communicate these advantages of theirs, in some measure, to the minds of their seniors. Natural young people are good company for everybody. They are, of course, good company for each other, and the solitary child is greatly to be pitied, *unless its elders are really still young in mind.* But above all are young people good company for their seniors. Those elderly people who, apart from special causes like illness, cannot put up with the company of properly behaved young people are already old in essentials, and betray the fact beyond any sort of doubt or dispute.

The Knack of Growing Young in the Company of Youth

The way to keep young is to be much in the company of youth. The great principle is, in Herbert Spencer's words, "Be a boy as long as you can." He who can spare some of his hours from the ways that are dark and the tricks that are vain of his adult compeers, to the company of children, will find that their interest in things and their joy of living are infectious, as every emotional state is infectious through the omnipresent mental fact we call suggestion. Thus old people can be observed growing visibly younger when they are put in young company.

The writer has seen an old woman, who had all her life been a nurse of young children, age on superannuation almost as visibly as Mr. Rider Haggard's "She" when her power left her. A new baby was put into her charge. Her "rheumatism" disappeared, her eyes brightened, life became worth living again, and for some years she could be observed to grow visibly younger. We have here, of course, a ready explanation of the fact that, if other things be only approximately equal, fathers and mothers look, feel, and are younger at any given age than their unmarried contemporaries. But when we praise the young for their use to the old in this connection, we should remember that this service rendered by the young involves some risk to themselves. They do not benefit reciprocally. Virtue goes out of them, but no corresponding virtue enters, except the negative virtue of discipline. Therefore we must be careful not to shut the young up, without relief, in the company of the elderly or old, unless, indeed, those fortunate seniors be truly young in soul. Not a few instances might be recorded where a tendency towards melancholy, introspection, and actual melancholia on the part of the young has been disastrously exaggerated by the lack of healthy young company.

The Possibility of Indefinite Mental Progress in Defiance of Age

Though it is true that we cannot learn the violin at twenty, and in general that the possibility of making neuro-muscular acquirements becomes severely limited after youth is past, yet, so far as the higher attributes of the mind are concerned, we should progress indefinitely. This capacity for unlimited mental growth is our unique privilege, just because we are not solely instinctive beings, but have that infinite, limitless thing called intelligence. In many of the animals nearest us there are foreshadowings of intelligent plasticity, but only in ourselves is the plasticity limitless. So far as the higher mind is concerned, we *may*, if we be wise enough, learn and change and grow in our eighties or nineties as at any other age. The "old dog *can* learn new tricks"—of the mind.

Sir Francis Galton as an Instance of a Man Who Would Not Grow Old

The late Sir Francis Galton, a great student of the inherited and fundamental factors of individual health, and not least of the factors of longevity, was himself a very striking example of the maintenance of mental youth in bodily old age. It was often remarked of him, and became a saying among his friends and pupils, that he was always "the youngest man in the room," even when he was not far from his ninetieth year. He always had the enthusiasm and optimism of a boy, with a thousand times as much judgment, and the only complaint he had to make of his years was that they dissuaded his juniors from offering criticisms. As if by way of a parable, he suffered from extreme deafness, but his mind was keener of hearing than ever; and no one who had the privilege of observing him could ever again confound the merely

physical deafness and disabilities of old age with that deafness of the mind which begins to come upon lower types of men and women in their twenties, and which is the chief bane of common old age.

One of the secrets of youth is to keep working; not necessarily money-making, but working. Everything, except spiritual old age, comes to him who works. Not only is it better to wear out than to rust out, but it takes much longer. Indeed, the mark of the living organism, as we watch it from day to day, is that it does not wear out, because, unlike other machines, it has the power of internal recreation. We have been evolved largely by the struggle for existence, and are therefore strugglers by constitution. When we cease to work, we degenerate. In five years after retiring from business or from work, a man commonly ages more than he did in twenty preceding years, unless he is fortunate enough to have some hobby or interest—children or china, or whatever it be—that saves him.

The Necessity for Always Learning Something, that the Mind May Go Forward

And just as one must keep on working, so one must keep on learning. Simply to learn for learning's sake is worth while, at this later time of life, for the sake of the mental gymnastic. The learning of Greek roots, the vagaries of irregular verbs and particles, and the like is a pitiable exercise for the child's mind. A great deal of the subject matter of what we at present call education would have a useful place, however, in filling the otherwise unfilled hours of elderly people. At any rate, if they can find nothing better to learn, it were better to memorise a page of irregular verbs than to learn nothing. From such verbs the learner may proceed to an interest in etymology and philology, such as keeps the minds of many elderly people alive. Entomology would do as well, or any other "ology" which means that the mind *goes forward.*

Another cardinal rule for the preservation of youth is to preserve the optimism of youth. It may be said that this is just what the old man, because he is old, cannot do; but that is only partly true, because it ignores the native, original powers of the mind in itself. If the old man finds occupation, and recognises the danger of incipient pessimism, he can protect himself. Here are some entirely admirable observations on the subject from Professor Forel, of Zurich, an authority among authorities. "The modern man wears himself out in restless earning in order that he shall be able to rest in old age. But when the man who has worked all the time gets old, he discovers that without work he can no longer exist. Only the idler and the pleasure-seeker who has squandered his life becomes even lazier than ever in his old age—if that is possible—because he has never exercised his neurones [nerve cells]. If anyone wants as happy an old age as possible, he must first of all never betray his optimism; second, never brood over the past and the dead; third, work away to the last breath, to keep as much of his cerebral elasticity as possible."

The Fatal Error of Living Too Much in the Past

Special attention may be directed to the advice not to brood over the past and the dead. This is of cardinal importance for the elderly. They *must* look forward. The penalty for the backward gaze is the penalty that was exacted from Lot's wife; you are turned into a pillar of salt, or something equally destitute of life. It is well and right to love and admire the past, to be grateful to it, and to learn from it. But never can it be right to live for the past. This is the only too common tendency of nations, institutions, and individuals, and the consequent fate of all is the same. The nation or institution or individual that would survive must live for the future. There may or may not be evidence of purpose in Nature at large; there must be evidence of purpose in man, or he is doomed. The mark of the old man who is not really old is the forward gaze, whereas to live for "the day that is dead" is to be dead to the day that is alive.

Life is Change, and so the Mind Must Be Open to Change

So little attention do we yet pay to Mental Hygiene that on every hand cases are to be seen where the body seems verily to have survived the soul. The mind has lost its capacity to change, and so is no longer alive—for "to live is to change," as Newman said. Death of the soul is a tragedy not for one but for all; some of these dead souls are very malodorous, and highly injurious to the public health. Those of us who love and admire ideal old age, wherein experience and judgment and charity and patience have been added to, but have not replaced, the enthusiasm and optimism and modifiability of youth, must in similar measure deplore, if not loathe, that real senility of soul, to be found at all ages, which has lost all ideals, all purpose, all onward vision, and spreads nothing but

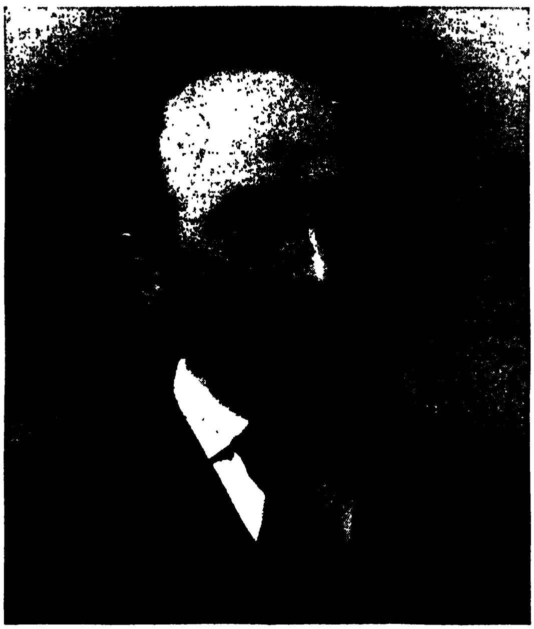
contagious death. On the other hand, it can hardly be possible to over-estimate the advantages which the society of the future will reap from the application of the scientific study of the mind—when old men as well as young shall see visions, and shall lead the world instead of lagging behind it.

In his well-known and admirable book upon the "Hygiene of the Mind," Sir Thomas Clouston, like everyone else who has adequately studied this subject, insists upon the value of occupation and purpose in old age, or rather in the postponement of old age.

"The typical environment of old age," he says, "consists of a quiet home, sons, daughters, and grandchildren, not necessarily living in the home, but frequently accessible." Cicero knew this, as readers of his famous book "On Old Age" will remember. Again, Sir Thomas Clouston insists upon the importance of the conscious effort to preserve the youth in one: "It is best carried out by seeing young people, by efforts to sympathise with them, and even by following at times and in a mild way some youthful pursuit or game." He continues, with these valuable observations.

"A gentle contentment with life comes naturally enough to normal old age. The very opposite state comes to the explosive and pathological variety of it. It is marvellous how happily nowadays many men and women of eighty get through the twenty-four hours. I met such a man lately, who had led a busy, intellectual, and practical life, and I asked him, 'Doesn't time hang heavy on your hands?' 'Not at all,' was his reply; 'I never was so busy in my life, the days seem too short for me.' He had, in fact, resumed hobbies and work of the right sort which he had not had time to do in his younger and busier days. Loneliness is certainly bad for the old. The brain and mind need the right sort of stimulus, and if they do not receive it they fall into a moody, selfish isolation. There is one trait which I have seen in some old people which is the cause of much misery—a jealousy of the young. The unreason of this is only equalled by its evil practical results, because it alienates and sends away just those social elements that might be helpful and hygienic."

If principles such as these were generally known and acted upon, what is too often the burden of the old generation upon the younger would be transformed into a boon. Human progress would be accelerated, and the reverence of old age, which, like other ancient and excellent things, is now out of fashion, would be warranted by the existence on all hands of old people, of both sexes, whose claim to "honour, love, obedience, troops of friends," was indisputable. It is one of the notable facts of recent vital statistics that the fall in the death-rate is mainly due to the keeping alive of elderly people under modern conditions. This is the same as what the alienists call the "accumulation" of the insane, causing an apparent increase in their numbers, merely meaning that they live longer. But it is of little use to live longer if senile dementia is the essential fact of the last period of life. This is only a death-in-life; and the problem for a complete hygiene today is to keep the mind alive as well as the body. And this is precisely where Metchnikoff, in his observations on old age, and the physiologists in general, fail us, for their studies are concerned with the body alone.



SIR THOMAS CLOUSTON
Photograph by J. Moffat

But if we are right in regarding the mind as the central reality of man, and in declaring that youth is a state of the soul, we must complement our physiology with an appreciation of the various psychical factors concerned, as we are here attempting to do. The mind depends on the body, we seem clearly to see, but the converse proposition is no less true, though the whole

tendency of nineteenth century medicine was to deny it. The body also depends upon the mind, and the factors of old age are therefore also to be sought among the psychical characteristics of "middle age," as it is commonly called. Doctors are in the habit of referring to "middle age" in their patients, somewhere after the age of forty, as a period when the individual must remember that he is "no longer young." The "middle-aged" man is told that he must begin to take more care of himself, that he cannot expect to have his former powers, and that, if he is wise, he will abandon the notion that he can enjoy life in all its variety as he used to do. The term "middle-aged" is thus definitely used as an *unhygienic* influence upon the mind. The man teaches himself to regard his condition as one of lost youth, begins to look anxiously for signs of actual decadence, and very commonly begins to coddle himself, on the ground that a middle-aged person requires to be careful of himself.

This is the double way, partly mental and partly physical, in which to hasten the advance of old age. Before the practitioner is entitled to give advice of this kind to his patients, he should study the normal facts of a human life-history. He will then learn that, as we have seen elsewhere, the period of "middle age" is really the period of *maturity* in the characteristically human attributes of our species, and should be so named accordingly. The bones, the muscles, the joints—which are the most mechanical parts of the body, and which are not characteristic of man at all—these already show signs of decadence in the period of middle age, and the wise man will therefore not attempt to emulate, in gymnastics or violent forms of athletics, the feats of his juniors. But in higher qualities middle age is really human maturity. As Professor Arthur Keith has lately insisted, the brain is at its best as an organ of thought after forty. The vital powers of resistance and control and self-management are also at their height in many respects. The man in his forties, therefore, who has taken proper care of himself, should regard himself as *mature*, not "middle-aged," and the problems for him are, first, to enjoy

"TIME GIVES TO HER MIND WHAT HE STEALS FROM HER YOUTH"—FROM THE PAINTING ENTITLED "THE BLIND ABBESS," BY MR. TALBOT HUGHES

and use and appreciate his maturity, and, second, to maintain it as long as possible.

The "cure" of old age can never be more than only the care of it, but the advent of old age can be postponed by the right care of maturity, and it is just in that right care that so many men and women fail. They quickly begin to follow the misleading and worse than worthless advice which is too often offered them. They begin to take care of themselves in ways which really mean over-indulgence, whether in food, drink, warmth, and idleness, and quickly they lose their only recently gained maturity of mind and begin to go down-hill. Of little use is it for the hygienist to tell the old man, or the victim of so-called "premature senility," that he should have taken wiser care of himself during middle age or maturity. Most advice comes too late in such cases. But surely something can here be done by way of warning to the man and woman in the height of their maturity as human beings. *Now* is for them the appointed time in which, by wise attention to the simple laws of hygiene, to avoid that artificial shortening of life and hastening of old age in which the hygienist observes most men and women of such ages to be actively engaged.

The Climacteric Changes that Come to Physical Life

Inevitably and naturally, there comes at length to both sexes a time when the part of our physical and psychical nature associated with the parental function begins to decline. This time is called the "climacteric." The "grand climacteric" was regarded by ancient authors as occurring at sixty-three in man, and that date very fairly represents the centre of the climacteric period in many cases. In women, though they live longer than men, the climacteric, or "menopause," as it is sometimes called, occurs much earlier, and this "change of life" usually has much more marked characteristics and accompaniments in women than in men.

The "change of life" is undoubtedly a period which involves special dangers for the health of the mind in many instances. This is notably a stage in the life-history of the individual when heredity tells, and when the inheritance of nervous instability may reveal itself, perhaps for the first time. A natural tendency towards a reduction of the output of energy is perhaps the essential characteristic of the change of life in both sexes. Sir Thomas Clouston has written so wisely and with such immense experience and authority on this subject that we cannot do better than quote a paragraph from his famous book.

"The meaning of the climacteric biologically is clear enough. It is the departure of one great function and a slow lessening of all the others. The rules of its hygiene, therefore, must be absolutely founded on those facts. The intense energising, the ceaseless thinking, the overdoing of all kinds of work and enjoyment, which might be allowable, if not continued too long at a time, during full manhood and womanhood, can no longer be safely practised when this period has commenced. All output must be lowered to the capacity of the producing mechanism."

The "Change of Life" as an Introduction to a Green Old Age

"The way in which some men and women suddenly collapse at this period either results from bad heredity or too much over-pressure for the period, or both combined. The weak points are beginning to come out, and must be carefully considered and allowed for if the remainder of the life is to be as effective as it can be, and as happy as the lowered energies permit of. To those for whom it is possible, a distinct resting-time about this period, a change of scene, a long voyage, a deliberate slackening of business or professional engagements, and a considerable change of diet are all desirable, and may make all the difference in attaining that green old age which everyone would like to enjoy. To adapt, in fact, hygiene to the physiology and psychology of the period seems not only common sense, but a duty which all men and women owe to themselves. The tendency among the strong and healthy is to resent Nature's sure law of decay, and to disregard her danger-signals until it is too late."

Wise Advice for Going Slowly Down the Inevitable Later Slope of Life

Observe that the principles which we laid down for maturity do not apply to the decadent period when maturity definitely yields place. What we said of the man of forty-five does not apply to the man of sixty-five. The strong and healthy man, with an active mind, who rightly declined to relax the strong tenour of his life in his forties, has now to recognise an inevitable fact of human life, which no resolution can alter. He must modify his behaviour accordingly, and very often, if he is wise, he will find that he can adapt his mind very well to the somewhat slackened tenseness of life which the post-climacteric period demands. And the man should remember

that, except in rare cases, he has less to endure at the climacteric than woman has.

The *tedium vitæ*—boredom with life—which was long ago described as the common characteristic of the climacteric, remains so to this day. Interest in life diminishes too often, " pleasures that cost little and imply small exertion are preferred to pleasures of the higher sort that need some strenuousness to attain them." The temptation towards excess of food and drink is often too strong to resist, and, as Clouston says, " many people take to alcohol then, because in them it seems to be the simplest way of reviving some of the intensities of their former lives, or of deadening the regrets which the conscious absence of these intensities creates." At the climacteric a non-stimulating diet is preferable, and it is probably well to cut down the amount of protein that has been consumed with more or less impunity in former years. Especially is this so for people in whose families there is any definite tendency towards gout or rheumatism, for this may be just the period at which such tendencies assert themselves if they get the chance. Fruits, vegetables, cereals, and fish are perhaps the safest and wisest diet for the climacteric period.

The Disabilities of the Climacteric No Cause for Grave Apprehension

But the mind is apt to show its weakest points at this time, just as the body is. People become the victims of obsessions of various kinds in many cases, and the reason does not seem to have its usual power of dismissing as nonsensical or trivial notions which really are so. It is against such tendencies, which may sometimes lead to actual insanity or suicide, in persons naturally predisposed towards mental instability, that we prescribe relaxation of mental strain, change of scene, attractive hobbies, and such-like allowances for the mind.

Let not the reader suppose that these various risks and disabilities of the climacteric, upon which we have insisted, are to be regarded with grave apprehension or with despair of ever emerging from them. On the contrary, the climacteric is exactly what it is called in popular language, the "change of life," and things regain a more stable state, though at a different level, when the change is completed. This is, indeed, only the obverse and correlative of that earlier period of transition which we call adolescence, and which also has its especial risks and complications. The train of events is most definite and demonstrable, as a rule, in women. They suffer far more than men at this period, and in their inexperience—for none of us pass this way but once—they may suppose, and often do suppose, that the joy of life, that everyday health and capacity for work and play, are gone for ever.

But this is very far from being the case. On the contrary, the climacteric period simply offers to each woman a kind of problem which she must deal with as best she may before she can find its solution. In proportion to the wisdom, the philosophy, and the common sense with which she meets this period may we expect her to find her problem solved thereafter. Here is Sir Thomas Clouston's summing up at the end of his discussion of the mental hygiene of this period.

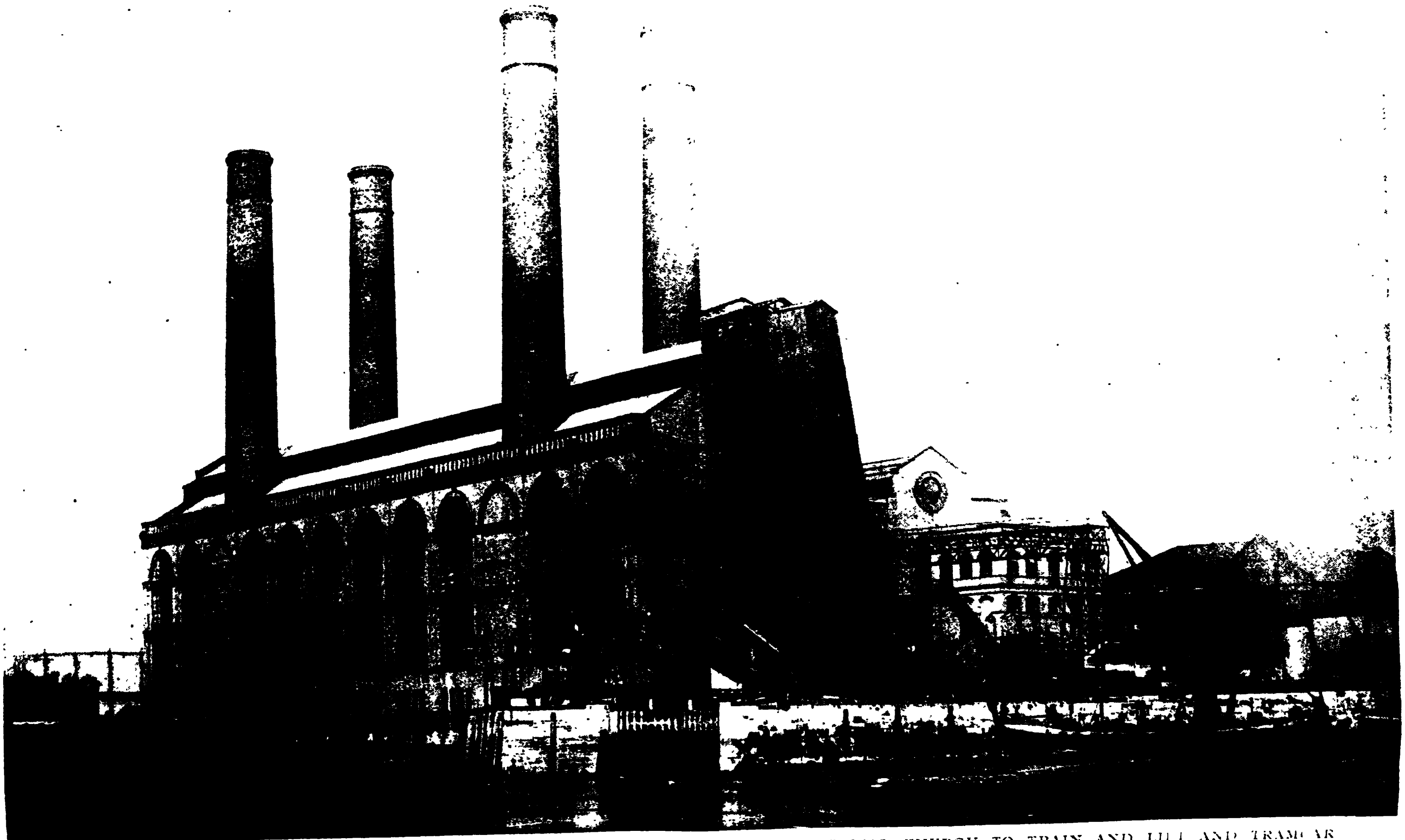
Some Manifest Advantages of Age when it is Wisely Welcomed

" Nature provides that there is a period of mental peacefulness, calm, and health, with even a reasonable amount of energy of the right sort in many cases, between the crisis of the climacteric and the beginning of old age. Especially in the female sex there is better health enjoyed at this nondescript period of life than has existed for twenty or thirty years previously. Many of the dangers and excitements of life have passed ; its passions have abated, and the powers of judgment and control have asserted themselves over emotion and impulse. Much good work, especially of the judicial and benevolent sort, is done at this period of life. If strenuousness is not so great, caution is enormously increased. The experiences of the former life are applied in a really effective way. Much happiness may be enjoyed if a too keen enjoyment is not expected or strained after."

Health and Happiness of Mind and Body a Continuous Possibility

With these wise and hopeful words from a veteran student of the mind, who has every kind of experience behind him, we may conclude our discussion of this subject. We have seen that there are certain natural periods of life, which we all illustrate, and to which we must all conform, until the inevitable end ; but we have also seen that the honest and scientific study of these periods and their transitions may help us to protect ourselves, and so to direct our lives that we may derive the most health and happiness of body and of mind throughout every year of life, from the advent of maturity until the coming, and the passing, of a ripe and honoured old age.

A MONSTER POWER-HOUSE IN CHELSEA THAT WORKS EIGHTY MILES OF LONDON RAILWAYS



ONE OF THE LARGEST POWER-HOUSES IN ENGLAND, WHICH TRANSMITS ELECTRICAL ENERGY TO TRAIN AND LIFT AND TRAMCAR

THE NEW ELECTRIC AGE

How Science is Ushering in a New Era for Mankind and a Finer Civilisation

THE UNIVERSAL SERVANT OF MANKIND

A HUNDRED years ago Watt's principal patents in his improved steam-engine just expired, and many engineers were busy developing the great prime-mover of the nineteenth century into its present forms. A few men of science were then playing with a little toy which no one of the wildest imagination would have dared to compare with the mighty steam-engine. But from a toy the electrical machine grew into a mystery that allured and perplexed the finest geniuses of the age, and very slowly it began to be seen that mankind was in a way to possess a universal servant that would carry out every task. Faraday's discovery that electricity could be generated by moving an ordinary magnet close to a coil of copper wire has now become the fundamental fact of our civilisation. As a consequence the age of steam power is passing into the era of electrical power.

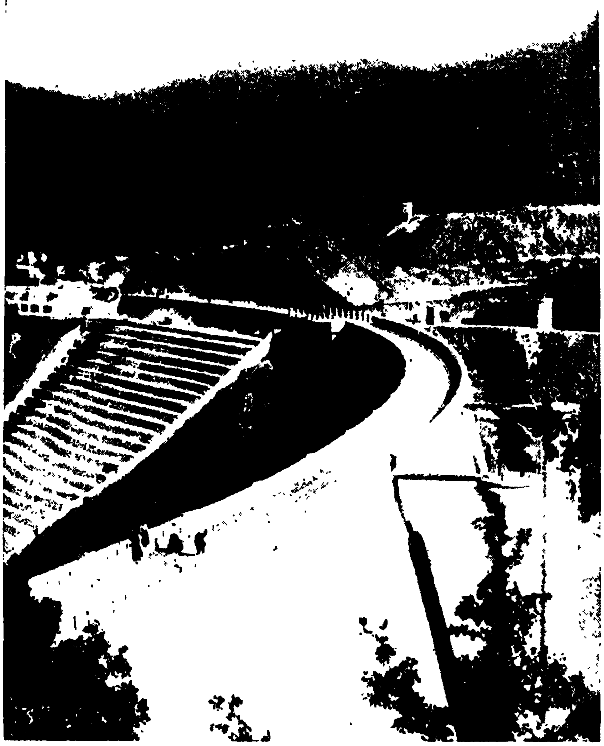
No one would have believed a hundred years ago that man would one day control a mysterious force that would take the energy of coal, of air, or falling water, and carry it by easy channels for hundreds of miles, and then put it to practically any kind of work. Yet now this mysterious force can be made, at a great distance from the place where it is generated, to give the light of a million candles, the power of a thousand men, to produce heat without combustion, to unlock the chemical bonds of matter, and release new substances. It can be made to proceed in a radiance that shines through flesh and steel; it can convey the human voice for hundreds of miles, and take human messages round the world in one-fifth of a second; it can drive a railway train with more economy than a steam locomotive; it can even sweep a carpet, act as an automatic waiter at meals, and afterwards wash up the plates. It is infinite in application, doing the lowliest of tasks as well as many marvellous works far beyond the scope of human hands.

Twenty-five years ago the electric age of civilisation was still but a dream of the future. Now it is in course of realisation. Very simple is the thing that has turned the dream into a reality. It consists merely of two coils of copper wire surrounded by sheets of iron. When an electric current—so intense as to be dangerous to life and useless for most industrial purposes—is sent into one of these coils, there is produced in the other coil, with no appreciable loss of energy, a current of electrical power of large quantity and low intensity, which is safely available for light, heat, and all sorts of domestic and industrial purposes. The thing that thus changes the quality of an electrical current is called a transformer, and upon it there is now being built the new electric civilisation. A quarter of a century ago currents of great intensity could be generated and transmitted to great distances with little loss of power, but no means were available for using this highly dangerous current for anything except electric-arc lighting. An intense current—or, to use the proper technical term, a current of high voltage—was absolutely necessary for the economic transmission of electricity. For a current of low voltage was safe, but wasteful, and even impossible at times to transmit. The invention of the transformer, however, completely changed the situation. It made it quite an easy matter to "step down" a current of high voltage and small quantity into a low voltage current of large quantity, or to reverse this operation by "stepping up" a low voltage to a thinner and more intense flow of electrical energy.

This gave our electrical engineers the means of controlling the marvellous power

they generated. They were able, so to speak, to take a small and very rapid stream of electricity and send it cheaply to a great distance along a thin copper wire, and then change it into a broad, slow river of working force that would not be perilous under ordinary conditions, and yet drive all sorts of mighty machines and small domestic appliances. It did not matter, within reasonable limits, how far away the source of power was. It could be brought for a hundred or even two hundred miles from a waterfall or a coal-mine, and delivered for lighting purposes at a cottage, or for power purposes at a factory. It was available for use on farms, for electrifying growing crops and increasing the natural produce of the land, for sterilising the water, milking the cows, and creating both heat and light, and the artificial cold needed to keep dairy produce fresh. It could even be used in a special plant for extracting from the atmosphere the fertilising chemicals needed in agriculture.

In the large industrial cities of our time it was available to filter, freshen, and fan the air, and do away with all the smoke, dirt, and poisonous fumes that sap the vitality of modern urban populations. It was the general servant of the city. It could run the lifts and iron the clothes, move the trains and trams, and cook the meals of the people, purify their water supply, give them a soft, suffused daylight in the hours of natural darkness, and provide them with music and with singing and the news of the day in their time of recreation. One great man of science went so far as to say that, with sufficient electrical power, he could make rain and sunshine. All that was necessary for the quick development of the electric age was a cheaper supply of electricity. This is now practical, as Mr. S. Z. de Ferranti pointed out a couple of years ago.

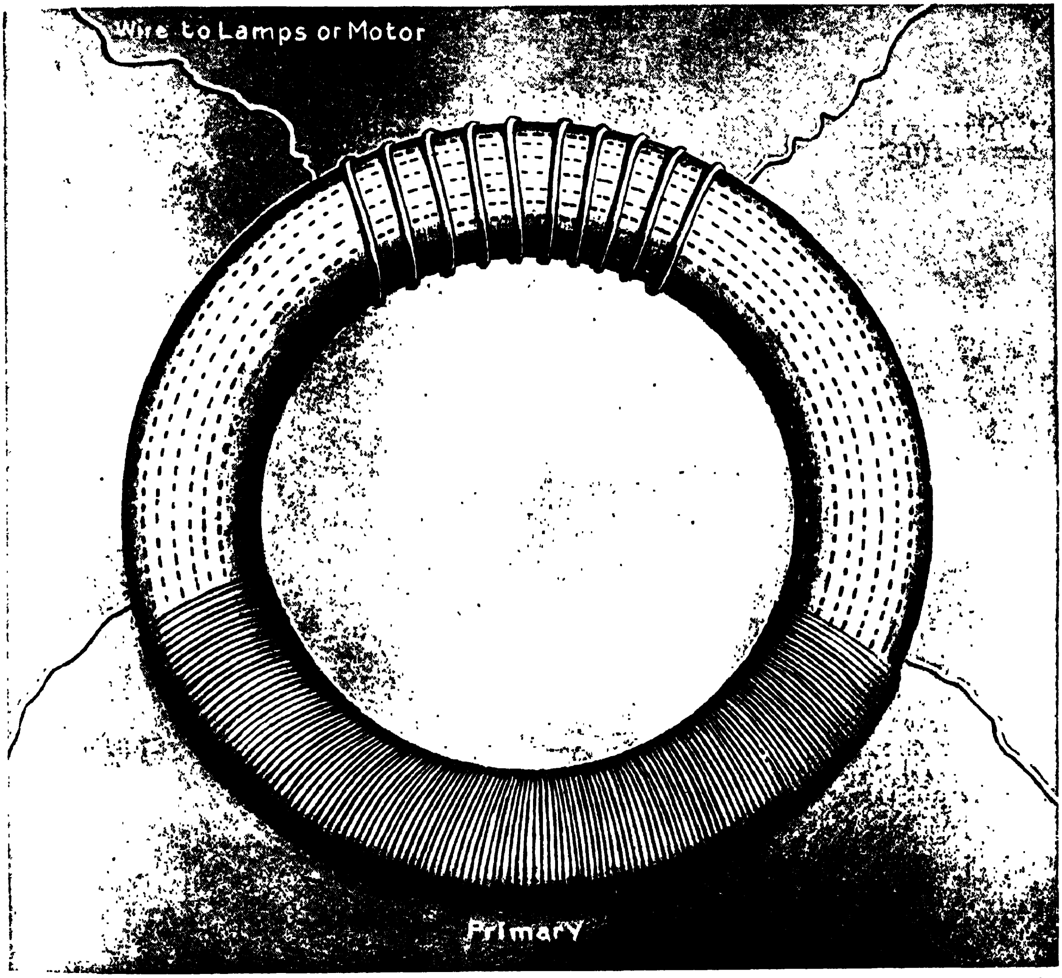


THE MASONRY DAM CREATING A NEW LAKE IN THE EIFEL VALLEY TO GAIN WATER-POWER FOR THE DISTRICT

The cost of electric current for power purposes has fallen from 8d. a unit to ½d. In some favoured spots, where electricity is cheaply obtained from water, the cost has fallen to one-fourteenth of a penny. What we need in our country, to establish fully the new era of electric power, is a constant and general supply of current, costing one-ninth of a penny to manufacture, and selling at the average price of one-eighth of a penny a unit. This would work out at a little more for small domestic purposes, and at somewhat less for large industrial concerns taking a big and regular amount of current. At the present time, about 150 million tons of coal are burnt annually in this country. Less than ten in every hundred parts of this stored-up energy is converted by us into work. Sixty million tons of coal, from which two and a half times the amount of work was got, would give all the power, heat, and light that we require. This extra amount of work could be obtained from a much smaller amount of coal, by centralising power production, and turning the heat of the coal into electrical energy in four or five big national plants situated in the coal districts. The coal would be turned into gas, and the gas would be used to drive the engines that generated the electrical current. The current would then be distributed to the distant cities, and to the towns and villages and farms along the way.

Out of the sixty million tons of coal used in this manner, there would be extracted, in addition to the electric power, sixty million cwt. of sulphate of ammonia. Practically all this valuable fertiliser is now wasted. Not only does it represent an annual loss of £24,000,000, but it is at bottom the present cause of all our troubles over our national food supplies. The sixty million cwt. of rich organic manure stored up in the ancient manner. We should recover the position in farming that we held in the middle of the eighteenth century.

The great increase in the fertility of our fields would save us from the risks of relying on oversea sources for our principal articles of food, and it would lead to the return of immense numbers of workers to the land. For there would be sufficient sulphate of ammonia saved from our coal to allow 143



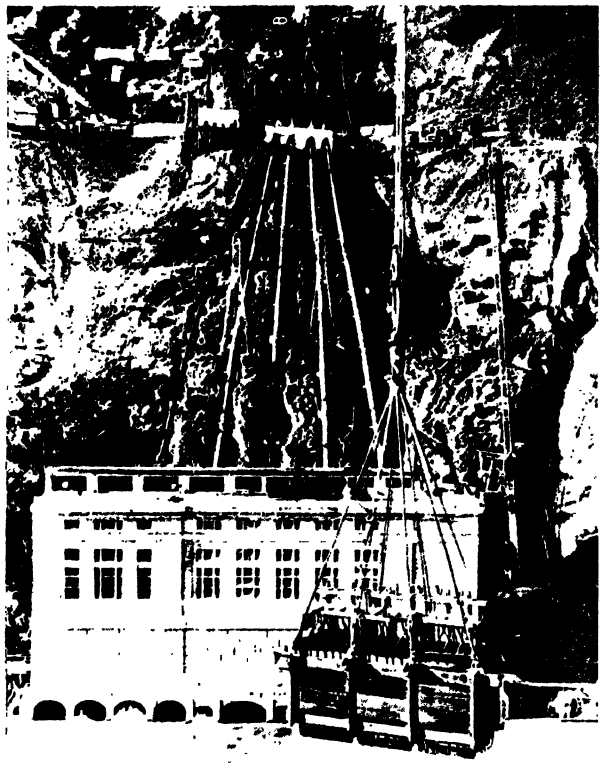
A DIAGRAM SHOWING THE PRINCIPLE ON WHICH A PRIMARY CURRENT OF 2000 VOLTS IS REDUCED TO A SECONDARY CURRENT OF 100 VOLTS ON A RING TRANSFORMER

In this ring transformer, the primary current, coming from the power-station at a high voltage, is sent into the first coil of copper wire that is closely wound round the iron ring. The electro-magnetic force then sets up or "induces" a secondary current of low voltage in the second coil of wire that is more loosely wound round the ring.

coal-plants, and wasted in our furnaces and hearths, would be sufficient to turn the soil of our country into the most fruitful of agricultural land. By using the fertiliser instead of wasting it, we could grow enough wheat and raise enough cattle and sheep to provide us with all the bread and meat we need. Our agricultural activities would be quickened and extended in an astonishing pounds of it to be used every year on every acre of ground. This, of course, is an average for the whole of our soil, and in practice some land would receive more fertiliser to the acre, and some would receive less. Being manufactured regularly, in so huge a quantity, and produced as a by-product in the generation of electrical power, the fertiliser would practically be as cheap as it

was plentiful. Moreover, there would always be times when the engines and dynamos were generating more electricity than was needed for industrial and domestic purposes. So, to keep the plant running continually in an economic manner, some means would have to be found of using the superfluous power in a new and profitable direction. It could easily be done by making fertilising nitrates from the atmosphere, as is now being accomplished on the Continent. This would still augment the annual production of fertilisers, and thus increase the productiveness of our fields.

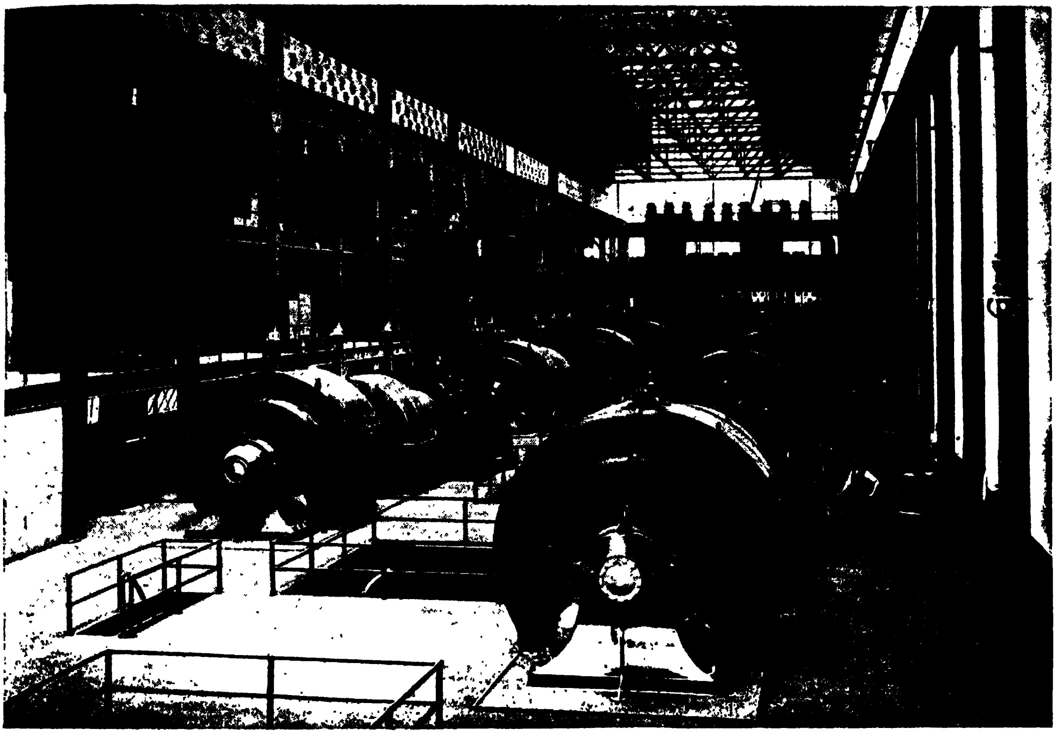
No great engineering difficulties stand in the way of realising this striking plan of Mr. de Ferranti. Some years before he proposed it, there were several schemes before Parliament for dealing on a very large scale with the supply of electrical energy to London. In one of the most important of these schemes, the Warwickshire coalfields were chosen as the site of the central power station. The proposal had the support of all the railways companies, and some of them agreed to the transmitting wires being carried along their lines for considerable distances. The whole thing was worked out in great detail, and over £20,000 were spent in Parliamentary expenses. But on the second reading of the Bills they were thrown out, on the official recommendation of the then President of the Board of Trade.



A POWER-GENERATING HOUSE IN CALIFORNIA
This picture shows the conveyance across the Feather River of a 10,000-kilowatt, 100,000-volt transformer to a hydro-electric station. The flumes conveying water down the hillside are shown behind.

The fact was that the existing interests in the supply of electrical power to London were very complicated and powerful. Over £17,000,000 of capital were already invested in a large number of small local generating-stations. There were private companies and municipal undertakings, all of which would probably have been destroyed if the larger simpler, and far more economical scheme of getting power directly from the nearest coalfields had been realised. So London will very likely be the last city in Great Britain to enter properly upon the electrical era of civilisation. The lead will come from the better organised big cities of the provinces, such as Birmingham and Manchester. Here there are no diversified interests to contend with. In both Birmingham and Manchester the electrical supply is in the hands of the local authorities. When they are ready to take the splendid and inspiriting opportunity of inaugurating the electric age, they will acquire such great advantages over the metropolis that London will at last be compelled to follow them. The cheapening of industrial power alone will give them so high an increase in manufacturing efficiency that their manufacturers will be able to undersell competitors in all the more backward centres of industry.

At the present time it looks as though the first great electric city will appear in America. For some months ago a large project was settled at Harvard University by which Boston is to be supplied with electricity generated hundreds of miles away in the great Pennsylvanian coalfields. Moderate estimates, we are informed, place at five years hence the date when Boston will have done away with its coal-carrying system, its smoky skies, sooty chimneys, and coal-dust-laden air. Coal strikes will not then worry the householder or the business man, for all the city will use electricity generated



THE TURBO-GENERATORS WHICH GIVE 65,000 HORSE-POWER AT THE CHELSEA POWER-HOUSE

THE GALLERIES IN WHICH THE CURRENT IS MEASURED, REGULATED, AND TRANSFORMED

over a far distant mine, where coal costs a few shillings a ton.

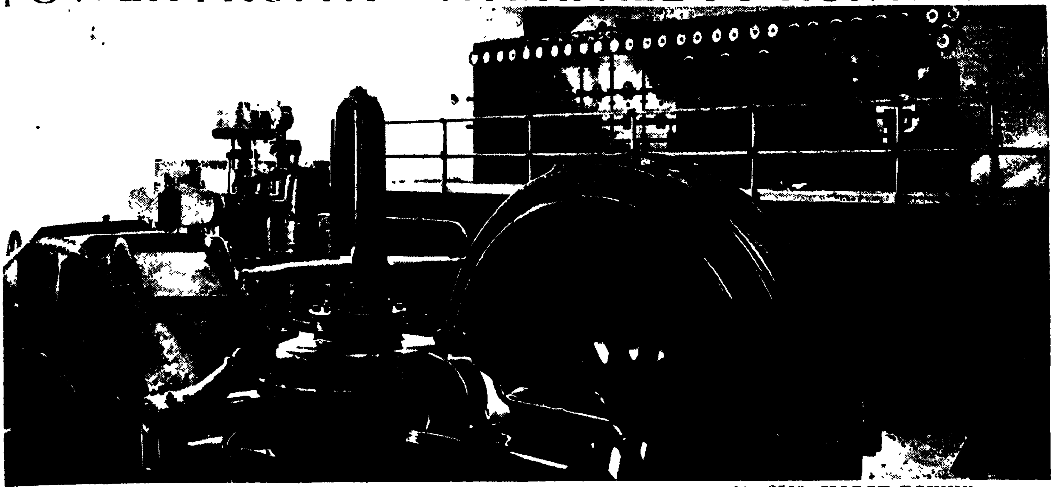
There is no difficulty today in transmitting electrical energy for a hundred and fifty miles or so. The Midland coalfields are less than a hundred miles from London; the Black Country is only one hundred and twenty miles away; whilst the Kent coalfields, about which there is now no doubt, are scarcely seventy-five miles from London. So what is being planned for Boston could be more easily carried out in London and our big provincial cities. All the materials for a great industrial and hygienic revolution are accumulated, ready for some man with civic patriotism and high organising genius. Surely our cities that produced the men who started the new era in the municipal control of water, gas, and local passenger transport will throw up another far-sighted organiser. But he will have to be strong enough to override the purblind selfishness of a small class of his fellow-citizens, and make electrical power obtained from the nearest coalfield do all the work of the city.

HOW WATER COLLECTED IN THE HILLS GIVES POWER TO THE CITIES OF THE PLAIN

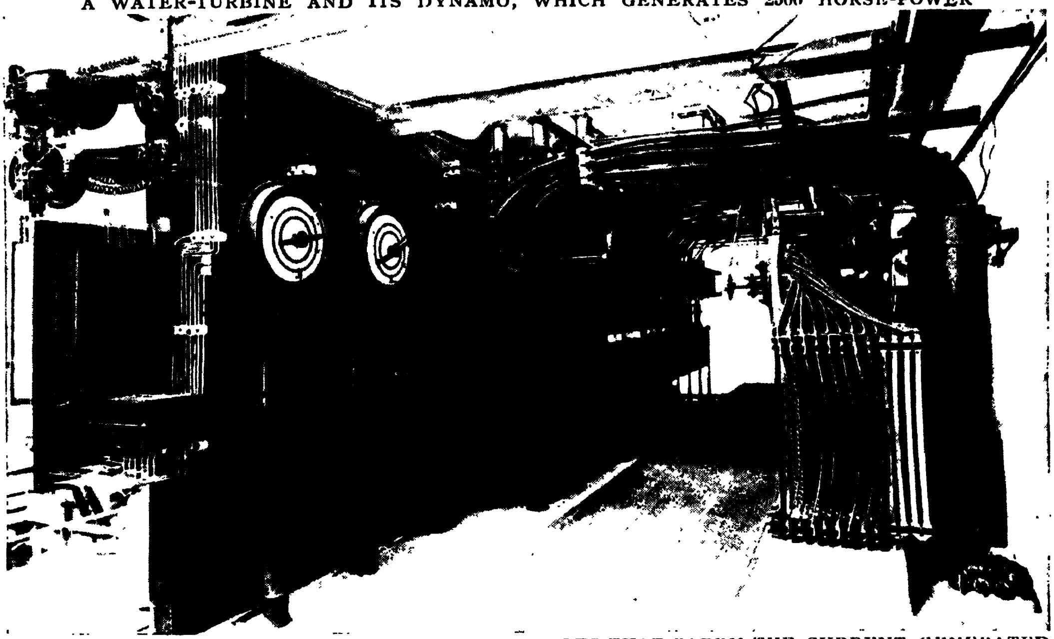
Naturally, there will be considerable opposition to the establishment of one cheap and general source of power. Manufacturers now employing their own steam-engines will be obliged to dispose of their present power-generation plant at second-hand, in a falling market. For they will have to use the new and cheaper source of energy, in order to compete with their more enterprising fellow-citizens. There will be an immense trade in electric motors and transformers, and in many cases, perhaps, new appliances for driving existing machinery will have to be installed. This will undoubtedly entail a very considerable expense on all classes of manufacturers in the first electric city. Probably it will mean bankruptcy to those who are on the edge of the industrial struggle. Small, young firms needing capital, and old-fashioned houses already on the downward path, will both be heavily hit. So they will fight with all their strength against the new scheme. On the other hand, the general body of citizens will benefit greatly by the revolution in the supply of power. The extraordinary cheapness of the new supply of electric energy will attract to the city enterprising manufacturers from other parts of the country. On the inauguration of the scheme, the field of employment will widen, to the advantage of the working classes. Then, as the city recovers from the struggle and shock of the transition, its productiveness will increase in a remarkable manner. In every department of industry in which its workers are engaged it will triumph in the open markets of the world.

In the industrial struggle of the age of steam, the individual was the great force. He had only to buy a steam-engine and set up a mill or factory where coal was cheap, and he at once obtained an advantage over the manufacturer who used the old-fashioned wind-power or water-power. The irregularity of wind-power, the periodic interruption of water-power in time of drought or freezing cold, enabled the manufacturer with the steam-engine to fight his way steadily to the front. He incurred more expense than his rivals, both in the prime cost of his engine and in the annual charges for maintenance and fuel. But the unfailing regularity of his productiveness was cheaply obtained; and after a

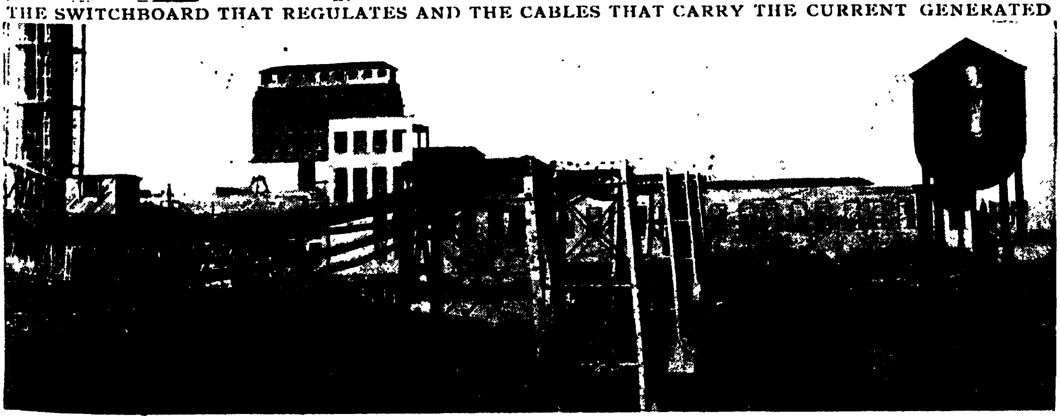
POWER FROM A WATERFALL TO RUN A MILL



A WATER-TURBINE AND ITS DYNAMO, WHICH GENERATES 2500 HORSE-POWER



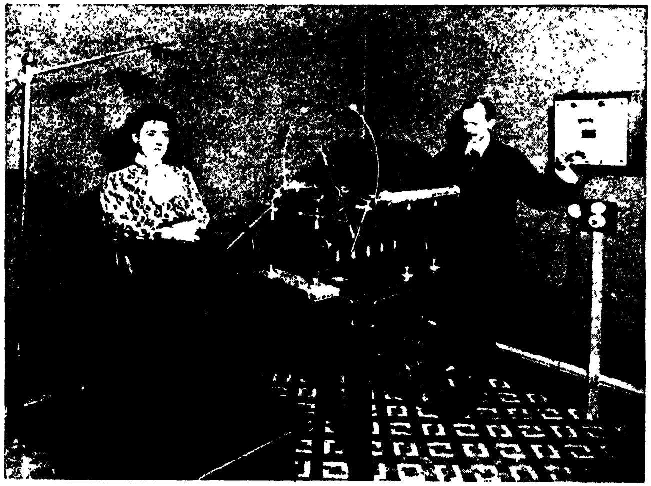
THE SWITCHBOARD THAT REGULATES AND THE CABLES THAT CARRY THE CURRENT GENERATED



SOME OF THE CABLES THAT CONVEY ELECTRICITY FROM THE POWER-HOUSE TO THE MILL

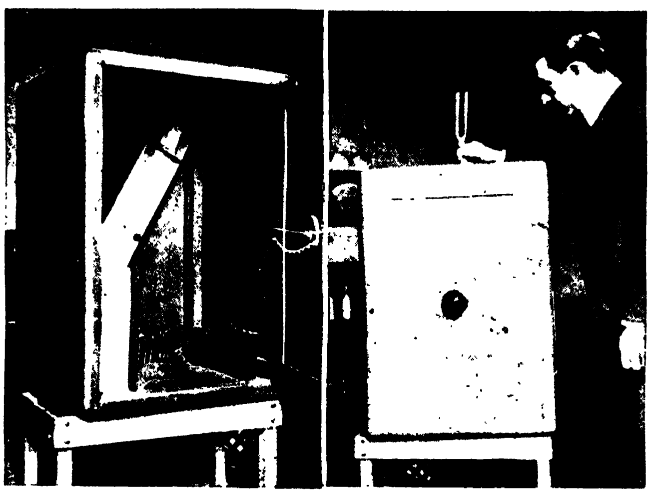
long, agonising contest the handicraftsmen and the users of windmills and watermills had to yield completely to him. It was an age of self-help. One man, with capital, initiative, and knowledge, could defeat a town.

The electric age will be an era of co-operation. It supposes too immense an outlay of capital, and too vast and intricate an organisation, for an individual here and there to profit singly by it. Possibly the joint-stock method of conducting an undertaking would be adequate, but we doubt if even this form of co-operation will have any large influence in the establishment of the electric city. The growth of municipal enterprise has, in spite of certain defects, brought about a revival of an intense and effective kind of local patriotism. In many of our large centres of urban civilisation there is now a spirit of civic fellowship, loyalty, and co-operation that is realising itself in fine civic works. Having got their own water, gas, and tramways, our cities will not permit the most important of all municipal enterprises to be taken away from them. The ratepayers will sooner or later co-operate in the veritable electrification of their city. They will acquire one of the nearest coalfields, and erect there the power-station from which their city will entirely be run. In many cases it is now only a question whether the local authorities, who have already the control of the electrical supply, will take the necessary steps to make that supply as cheap, as efficient, and as general as it ought to be. The thing can only be done in a large and wholesale manner. So the old individualistic spirit of self-help is quite powerless to effect the next great revolution in industry.



MEDICAL ELECTRIC TREATMENT FOR NERVE DISEASES

The electric age is therefore an open field for civic co-operation. When it is inaugurated we shall probably see a struggle between town and town for the best and most convenient sources of power. In some countries the cities of the plain will fight against each other for the water-rights over a neighbouring mountain range. In others, the coalfields will be the subject-matter of a great Parliamentary battle. And there will be a general and healthy competition for the services of the best electrical engineers, and a keen rivalry in all the processes of generating and distributing electricity. What is now our national loss may then prove our national gain. We are now suffering from the fact that we do not possess a corporation in electrical engineering similar to the General Electric Company of America, and the A. E. G. of Germany. These two very powerful companies have done much to promote the electrical engineering of their own lands.

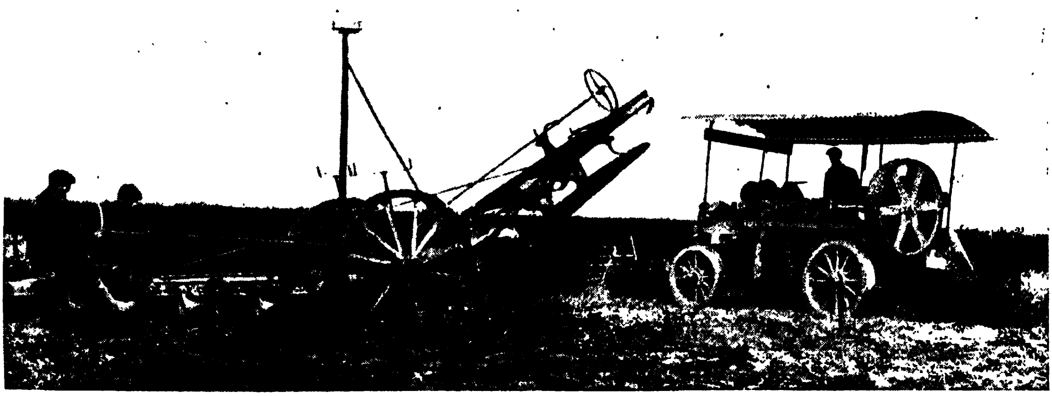


HOW ELECTRICITY AND A NOTE FROM A TUNING-FORK OPEN A SAFE

and have invaded and conquered a good deal of our territory. They each possess a staff of able men of science, who continually enrich them, and extend their power by researches and inventions.

We have no private firm that can make much headway against them, and their continental resources are constantly increasing. It is partly due to the fact of the interests of our inventors and undertakers of electrical enterprises having been damaged by an undue regard for the municipal authorities that we have lost in the international race for the new electrical industries. Though we were among the first to take up in a large way some important branches of electric engineering, our men of enterprise were checked and defeated by Parliament, in favour of vague municipal schemes that were slow in market, free to the energetic inroads of foreign electrical corporations.

But if only the governing bodies of our cities will do their duty in the new electrical age that is opening, we may more than recover the ground we have lost. As we have seen, several important civic authorities have now a general control of the electric supply. They possess, therefore, the means of cheapening and enlarging the service of power. The noble task of transforming their city into a bright, smokeless, and highly prosperous centre of industry lies entirely in their hands. If public opinion were fully enlightened on all the various benefits of a practical electric city, we do not think that Boston five years hence would remain long without a rival in Great Britain. All that the American town is doing could be done more easily by



HAULING A PLOUGH ACROSS A FIELD BY ELECTRIC POWER FROM AN OVERHEAD WIRE

realisation, and, in actual practice, parasitic rather than progressive. That is to say, none of our local authorities took any considerable part in the work of invention and experiment necessary in developing the foundations of the electrical age.

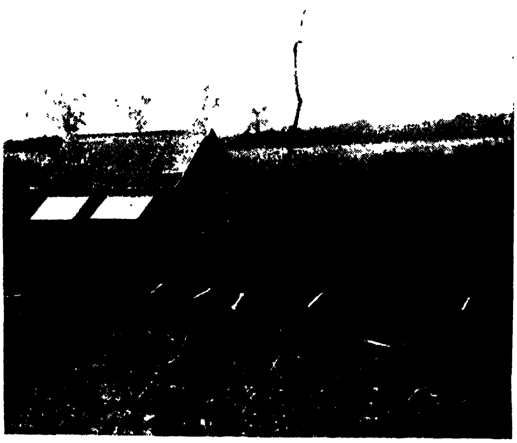
They left it to private men and to foreign companies to originate and test the new appliances. In other words, they monopolised most of the large opportunities of the new science, but did scarcely anything in the real evolution of the new force. They were the democratic representatives of the old French nobility—privilege without duties. They contributed nothing of importance to our national strength in the electrical industries. They merely defeated the private enterprises of the country, and left the markets of the world, and much of our own

our great Midland cities. For they would not have to go some hundreds of miles for a coalfield. Several cities have mines in them.

Perhaps, in the remoter future, coalfields and streams of falling water will not be the only large sources of power of the electric age. Already a foreign engineer is making a magnificent attempt to obtain electrical energy from the tides of the sea. For the last three years, Mr. Pein has been building a series of sea-walls connecting Nordstrand, a little island in the North Sea, with the mainland of Schleswig-Holstein. The works form two gigantic reservoirs, one about 2250 acres in extent and the other 1500 acres. The smaller reservoir will be filled with sea-water at high tide, and the great reservoir will work at low tide. Strong currents will sweep in or out of the two reservoirs all day

and night, and the ceaseless movement of the water will turn a number of powerful water-wheels. Attached to the water-wheels are dynamos for transforming the water power into electric power, which will be conveyed by wires all over the country. The sea-walls are completed, and Mr. Pein is now engaged on the electrical plant.

It is hoped that in a few months everything will be in working order. If the scheme is successful, man will at last have done what he had long and vainly dreamt of doing—he will have harnessed the stupendous and now wasted forces of the sea-tides. The success of the affair may prove of great importance to our island country. For on our coast there are probably several places where two lines of sea-wall could be erected with stone from some neighbouring quarry. Indeed, Pein's

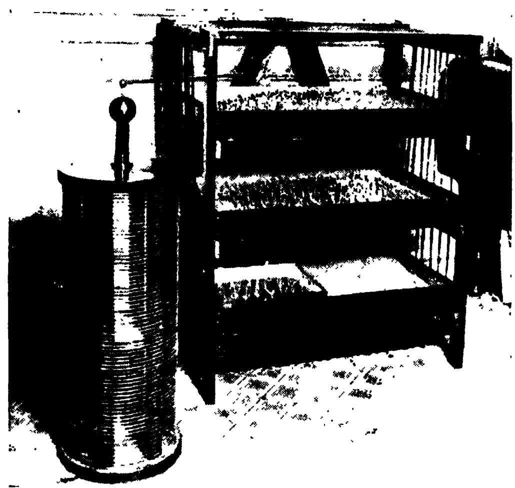


ELECTRICITY ON A SMALL HOLDING

plan is only a magnification and modernisation of the old sea-water mills that used to be worked along our shores. All this, however, is still rather remote, like the speculation of obtaining a regular supply of electricity from the new Danish windmill, and the new accumulator of minutely porous lead. But unbelief is the supreme folly.

More important at present are the electrical power schemes that are being worked out in the Scottish Highlands. Foyers, the famous waterfall in Inverness, has been harnessed and made to yield about 7500 horse-power. Then from Loch Leven, also in Inverness-shire, 30,660 horse-power is obtained. The water is dammed up in the mountains, and brought five and a half miles to a new township, Kinlochleven, which has been created for the manufacture of aluminium. In a wild and rugged district, haunted a few years ago only by wildfowl, there is now a bustling little town, with no slums, where the workers and their families have pure air, pleasant homes, with the sea at their feet, and ample space around. Fifteen hundred men take part in the making of aluminium.

The raw material is brought to them from abroad. It is the cheapness of their electrical supply that gives them the advantage. Twenty years ago, before the electrical method of manufacture was employed, the price of a ton of aluminium was £3256. It is now from £80 to £90. On the edge of Inverness-shire is another mountain lake, Loch Ericht, which will soon be harnessed to an electrical dynamo. By constructing an embankment, the water level can be raised another 15 feet, and then drawn off



GROWING CRESS INDOORS BY ELECTRICITY

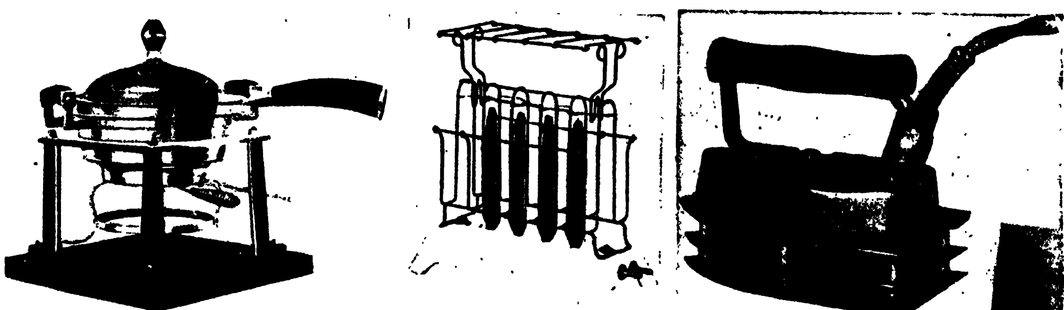
through a set of turbine-wheels connected with the electric generator. Some large industries are being developed in a similar way in Norway and Switzerland. But Scotland has the advantage over Norway in that there is no stoppage in the wintertime through the water supply freezing solid. At Foyers and Kinlochleven the works run steadily all the year round, while in Norway the electrical energy is often cut off for several months.

In the lowlands of our country we see little or nothing of the tremendous change that is taking place in the generation of electricity from falling water. Dr. C. P. Steinmetz, the mind behind the powerful General Electric Company of America, is inclined to rank the water power of the world above that of the coal-mines. In his

opinion, the store of anthracite coal will not last very long. Some of us will probably see the end of it. The next generations will live in an age when even soft coal is becoming scarce. We have already approached the end of wood fuel; and oil is too insignificant in its available supply to come into the larger problem. When the world reaches the end of its coal resources, the only thing that will keep men from freezing will be the power of water, which they will have to utilise electrically.

Few people realise the extent to which water power is being used even today. In the future it will be the world's only hope. When this time comes, there will be no more rapid rivers and creeks. They will all be slow-moving pools, connected by power-stations. There will be no cataracts, for the water will be dropped through tubes, from one level to another, to turn water-wheels. No question will then arise of preserving the beauty of the landscape. The first erected. But year by year the armoured concrete will weather in the air and light, rain and snow. The cement and sand will darken, the brick will take on subtler tints, and by imperceptible degrees the great structure will melt into the landscape, and become a thing of beauty as well as strength.

Much of our love of ancient loveliness is merely a distrust in our own taste. Lacking the power to discern between beauty and ugliness in the works of our own age, we spend our admiration upon things of antique beauty commended to us by tradition. Undoubtedly, the engineering achievements of the age of steam are more remarkable for strength and precision of design than for æsthetic qualities. Still, we must leave posterity something to accomplish. At present we have to labour in the development of the electric age, and make our urban civilisation clean and bright, healthy and leisurely. We have to



ELECTRICITY IN THE HOME—A CHAFING-DISH, A TOAST-MAKER, AND AN IRONING-I

electric power will be needed for heating, cooking, manufacturing, and warmth. It will be a question of saving the life of the human family, and that question will take precedence over the beauty of Nature.

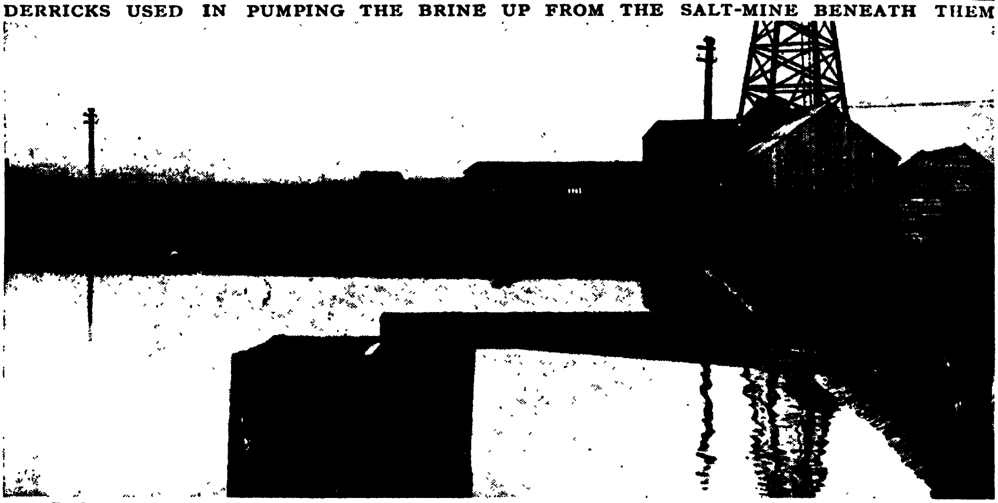
Power-stations, however, need not be ugly. They are centres of strength, like the castles that once commanded our country-side, and now rise in picturesque ruin among the hills. There are already in Europe modern power-stations, built by falling streams, that add a dignity to the natural scene. Monuments of man's dominion over natural forces, they gleam in the distance on the green heights with somewhat of the majesty of a fortress. And they are fortresses—houses of power, not over one's fellow-creatures, but over Nature.

Well proportioned and strongly built, they now stand white and bare and distinct from their surroundings. So a Norman stronghold looked in the days when it was subdue the mysterious, gigantic power we have recently discovered, and convert it into the universal slave of mankind. We must cheapen power to free our fellow-men from poverty. Perhaps we shall have to deface, by our power houses, the seashore as well as the mountain lake and torrent.

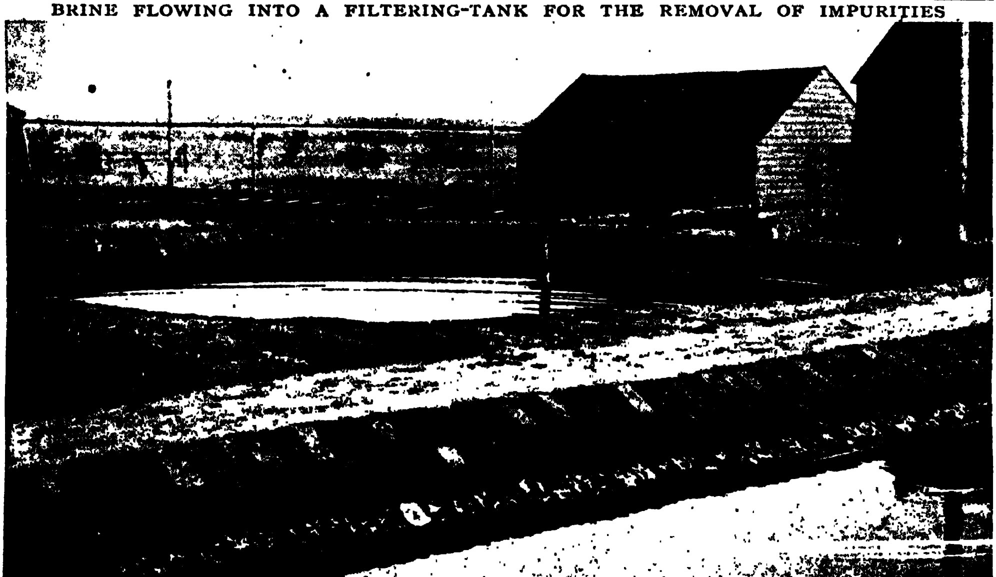
Even the silent and empty deserts of the tropics may have to be covered with vast plants of silvered-glass boxes, for catching the heat of the sun and converting it into industrial power. Each height in the future may be crowned with a windmill; and the telegraph lines that run along our main roads will only form a small part of the network of electric wires covering every civilised country in the electric age. If this is so, we must leave to our descendents the task of transforming our growing strength into sweetness. They will have at least a glorious heritage of power, and theirs must be the task of beautifying it.

THE PURIFICATION OF TABLE SALT

DERRICKS USED IN PUMPING THE BRINE UP FROM THE SALT-MINE BENEATH THEM



BRINE FLOWING INTO A FILTERING-TANK FOR THE REMOVAL OF IMPURITIES



THE RESERVOIR FROM WHICH FILTERED BRINE IS PUMPED INTO THE FACTORY

The photographs on these pages are by courtesy of Cerebos, Ltd., The Salt Union, and others.

THE MAKING OF SALT

From the Primitive Salt-Lick to the Modern Electric Soda-Factory

THE INDUSTRY THAT LED TO COMMERCE

SINCE mankind turned from a wandering to a settled life, the obtaining of salt has been the most important of industries. Only where savages retain the brutal habit of drinking the fresh blood of the animals they kill is it possible for them to do without common salt. There are few things more distressing than salt-hunger, and one of the most dreadful forms of torture the Chinese practise is to provide a prisoner with ample nourishment but insufficient salt. Purely vegetarian peoples have from prehistoric times fought their way to the sea in order to obtain salt. This cause of migrations has recently been discerned from a study of the movements of the black races of Africa. In recent times, inland African negro tribes have been known to prize salt above gold; for a handful of it a slave girl could be bought. Mungo Park related that some negroes had a way of referring to an extremely wealthy man as one who "seasons all his food with salt" -the most extravagant form of luxury they can conceive. Apparently it is almost as bad as lighting a pipe with bank-notes. We know how highly esteemed salt was in Biblical times, by the sanctity of the "covenant of salt." The modern Arabians, it is said, only practise the covenant of salt on occasions of the highest importance, as when one of their princes places himself under the protection of a Turkish pasha.

There are thus many reasons for supposing that salt was the earliest article of general barter. Food, clothing, and other necessities of life the warring tribes could obtain for themselves, but inland peoples were obliged to trade for salt with seaside nations; and so commerce on an international scale originated. The rarity and dearness of salt in ancient times were, of course, due to difficulties of manufacture. It is plentiful enough in sea water. The oceans contain 4,800,000 cubic miles of salt, which is about fifteen times the bulk of the continent of Europe above high-water mark. It would cover an area as large as the United States with salt crystals more than a mile and a half deep. There are also 325,000 cubic miles of rock-salt beds known to exist on the earth. Indeed, it is mainly from the brine pits and mines of this apparently small extent of solid beds of salt that the modern supplies of the world are obtained. It is owing to the strength and purity of our brine-pits in Cheshire and elsewhere that our country occupies so commanding a position in the alkali manufactures.

With the progress of science and civilisation, salt has grown in importance and value. For, as soon as it was known to consist of forty parts of the silvery metal sodium—which is as soft as wax, lighter than water, and caustic—and sixty parts of chlorine—a yellowish-green, heavy, irritant gas—chemists began to use it in new ways. From it they made carbonate of soda, bicarbonate of soda, and caustic soda, together with hydrochloric acid and bleaching powder. Glass-makers and paper-makers, soap-makers, dyers, bleachers, and wool-scourers depend now on chemicals made from common salt. From an old salt-mine in Prussia there is obtained much of the potash used in various manufactures, and employed as a fertiliser by the principal agricultural nations. So it will be seen that the salt industries have increased in value with the progress of civilisation. Salt is still a vital food for almost every race of mankind, and those that do not use it are, like certain Siberian tribes, low savages, who obtain the salt they need by drinking fresh blood. Further, besides being an article of food, it is the source of a number of chemicals of wide industrial importance.

There are three principal kinds of salt—sea salt, rock salt, and brine salt. That made from sea water is of the most ancient use. Even animals are acquainted with the salt-licks, formed in certain shallow bays by the evaporation of brine in the hot sun. In prehistoric times, men began to make by the seaside artificial ponds, into which they could at will let in a flood of sea water, that would evaporate in the sun and leave a deposit of the tiny white crystals that were useful in preserving meat and seasoning foods. From these primitive salt-beds were slowly developed the scientific salterns now used in Italy, Spain, Portugal, France, and Austria, in the Mediterranean; at Syracuse, in the United States; and continued in more old-fashioned forms along the shores of all the continents.

A saltern usually consists of a number of condensing-beds, arranged in a slope, through which the brine flows gradually, increasing in density as it approaches the last condenser. From this it gravitates into the crystallising-beds, or is pumped up to them. It often happens that an arm of an estuary, an inlet, or a silted basin can be banked off from the sea. This forms an admirable brine reservoir, where much of the suspended matters in the water can settle, while a slight process of evaporation goes on. A flood-gate connects the reservoir with the sea, and a pipe carries the clear water from the reservoir to a shallow pool fronting the condensing-beds. Usually, an open channel connects this pond with the first row of condensing-beds.

Each bed has a very large surface, with a depth of only a few inches, so that the drying action of the air and the sun may take effect quickly. In the first series of beds the brine only thickens. But as it runs in gutters to the second and lower crystallising-ponds, the salt begins to form in a crust on the liquid. The saline incrustation of the crystallising-pond is broken up and collected in small heaps on the embankments by means of rakes. The sea salt, however, is at first very impure, the impurity consisting chiefly of chloride of magnesium. This is got rid of by forming the smaller heaps into big stacks, and letting these stand for a long time with a covering of straw. The straw keeps the rain off, and the moisture of the air slowly dissolves the chloride of magnesium, and separates it from the mass.

Formerly, the lye, or mother-liquor, that remains in the last crystallising-ponds was allowed to flow back, as waste, into the sea.

A GENERAL VIEW OF CRYSTALLISING-BEDS WITH WORKERS RAKING IN SALT THAT HAS BEEN DEPOSITED

But this thick brine is now often run into a shallow pond of beaten clay about an acre in extent. It contains a considerable quantity of valuable chemicals, especially sulphate of soda and chloride of potassium, one of which can be extracted by cold and the other by heat. There was a time when the mother-liquor was exposed in winter for the sulphate of magnesia to be deposited, and then pumped up to a covered reservoir, and preserved until the following summer, when the chloride of potassium was obtained by evaporation. But this method is too costly and troublesome. Artificial cold is now applied to the waste liquor, and the chemicals are extracted from it at once. It is reckoned that 250 acres of salterns in a warm, southern climate will produce ten thousand tons of sea salt. But a spell of bad weather between March and September, when the evaporation is being carried on, sadly interferes with the production. For the process so entirely depends on the sun and the moon that in a wet season scarcely any salt is formed.

At Hayling Island, near Portsmouth, the manufacture of salt from sea water was carried on long before the Conquest. St. Augustine praised this salt for its excellence. Until recently it was still made during the four summer months. The beds varied in size up to a quarter of an acre, and in favourable weather the sea water in them became brine in seven days. It was then

COLLECTING THE PILES OF SALT FROM THE EVAPORATION-PANS AT BENGHAZI, TRIPOLI

pumped by windmills into pits, from which it ran into iron pans. It was boiled for twelve hours, and skimmed to remove impurities. The crystals of salt were shovelled out, hot and wet, into wooden trucks, from which the mother-liquor ran off through holes in the bottom. At Lymington the brines were passed through a series of condensing-beds, in the Mediterranean fashion, and then pumped into the boiling-pans. As late as the middle of the eighteenth century the duties on salt paid by the town amounted to £50,000. Fifty years ago salt-making was still carried on there, but now the brine-pits of Cheshire, Worcester, and Durham are worked so well and economically that sea-salt making has become an unprofitable occupation in our country.

The mode in which deposits of rock salt are worked depends very much upon the locality, the depth of the bed, the price of fuel, the rate of wages, and so on. In some places it is a mining operation, and it is carried on by means of shafts and horizontal galleries. The most famous of salt-mines is that of Vieliczka, in Austrian Poland, which probably contains the largest and the purest deposit in the world. The bed is said to extend for five hundred miles, with a breadth of twenty and more miles, and a depth of 1200 feet. Being an underground city, hewn in the course of ages in glistening rock-salt in the heart of the earth, the Vieliczka mine is the most surprising monument of human labour in existence. It lies below the quiet Carpathian valley of the Vistula, some miles away from the Cracow railway. For the miners refused to allow the line to come near to them. It was feared that the vibration might cause the upper earth to fall in, and bury the thousands of inhabitants of the strange crystal, sparkling streets, with their little pony tramways, drawn by animals blind from their birth.

Hundreds of years of patient human toil have honeycombed out of the solid rock salt an entire city at various levels. It consists of an intricate maze of winding streets and dim, scintillating alleys, of pillared churches, diamond and ruby staircases, restaurants, railway stations, shrines, statues, monuments, and a thousand other wonders—all rough-hewn in the sparkling

HARVESTING SALT WITH A PLOUGH FROM DEPOSITS IN THE CALIFORNIAN DESERT

rock-salt crystals which, when lit by electric lights, pine torches, magnesium flashes, or thousands of candles, blaze like a world of precious stones. Lifts descend the abysses leading to this fairy city, but there is also a long, massive staircase cut from the solid rock, which flashes in ruby and emerald gleams at every step.

About two thousand men work night and day in the underground city in eight-hour shifts; and, as a rule, they earn scarcely a shilling a day. The mine has been worked since 1251, yet its resources have scarcely been touched, so immense are they. What distinguishes the Polish miners from all others is their love of art. Far from being

depressed in their strange underground city, they have, for some hundreds of years, given a great deal of their spare time to carving huge monuments and innumerable statues out of the glittering rock. Emulation must have been the secret of all their gigantic art-work. It seems that no sooner was the first shrine chiselled from the salt, the first statue carved, than succeeding generations of miners were fired with zeal and determined to exercise their genius for sculpture. The salt-hewn cathedral of St. Anthony dates from the seventeenth century, and was planned by a pious foreman. The miners carry their religion with them to the depths of the earth, and strange and touching services are held in the rock-salt churches. Many of the men are musicians, and they have their own orchestra for festive occasions.

Some 300 feet away from the cathedral is a magnificent cavern cut from the rock. It is over 300 feet long, and towers to a height of 190 feet. Along its flashing walls are great statues of Knowledge, Labour, and other symbolical figures. At one end is a rock-salt throne of State, kept for the use of the Emperor of Austria-Hungary and the Imperial Archdukes. Whenever an old working is exhausted and closed, or a new street opened in the subterranean city, the event is celebrated by a dance in the great hall. Hundreds of picturesquely clad peasant women—wives, sisters, and sweethearts of the underground workers—take their partners into the cavern, where shrill pipes and soft flutes and violins make merry music as the couples whirl in wild Slavonic dances.

What adds to the strange beauty of this subterranean city is the illumination. The immense halls, restaurants, churches, and other public buildings are lighted by great chandeliers of salt crystals. One of them is 10 feet in diameter, 20 feet high, containing about two hundred and forty candles. There is a central railway station, where meet all the little trolley lines of the city of salt. It is three centuries since it was made the centre of the town. Many of the principal streets converge from it. The lines are narrow gauge, the little cars being drawn by Polish ponies, most of which have never been on the earth, and are born blind. The platform of this great central station has seating-room for four hundred persons. On holidays its cafés are crowded with visitors from the upper world, who take their meals to the wild music of the miners' orchestra that echoes and reverberates strangely through the dim and yet sparkling streets.

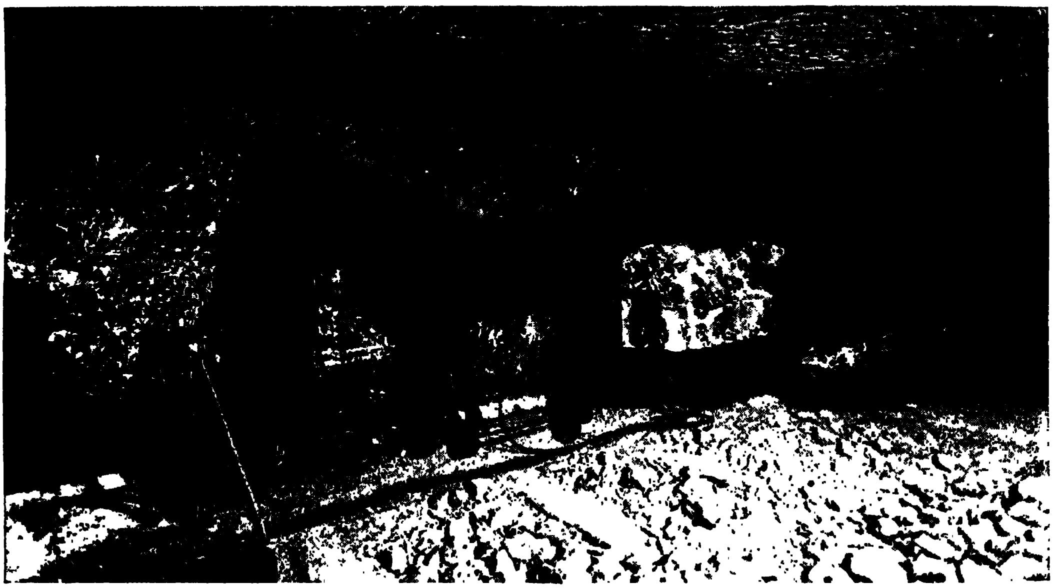
AT WORK IN THE VAST SALT-MINE THAT EXTENDS FOR 500 MILES UNDER AUSTRIA

There are also waterways in this weird city. In many places the saline lakes are from 20 to 30 feet deep, and over them ply ferry boats, holding a couple of dozen passengers. The boats give access to the remote and very ancient parts of the mine, such as the Stephanie Grotto, where rock-hewn statues of mediæval saints arise out of the dense salt water, girt and enshrined, as it were, by curiously beautiful salt stalactites and stalagmites. The lakes are fed by subterranean springs, and they are a source of peril to the miners, for they sometimes rise suddenly, and drown the workers in the lowest galleries. The inhabitants lead, indeed, a hazardous as well as a hard life. Great masses of rock salt, often weighing hundreds of tons, fall now and then in avalanches from the domed roofs of the streets or the ceilings of new chambers.

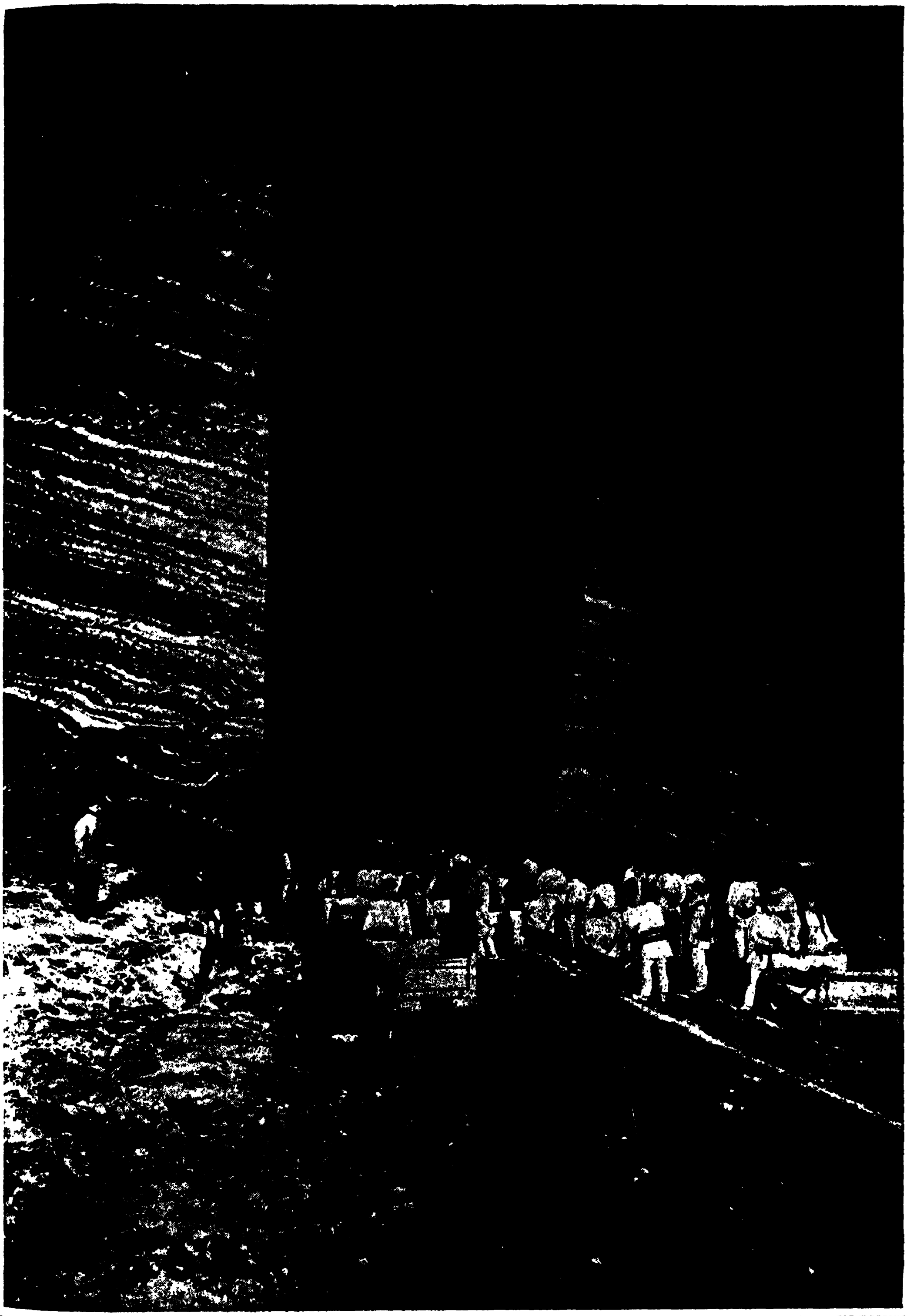
Besides floods, fires, and falls of rock—all of which catastrophes put on a ghastlier horror in the depths at which they occur—there is another serious danger of violent explosions from the gas that accumulates in newly excavated galleries. Yet for centuries these disasters have not daunted the thousands of inhabitants of the strange city of salt. Children are born and christened in the underground caverns, and, growing up, they continue the work of their fathers. Extending along the Carpathian Mountains for five hundred miles, the rock salt out of which the churches and halls of Vieliczka are built is mined at many other places—in upper Austria and Hungary, in Tyrol and Styria, in Transylvania and Wallachia.

In the New World, an immense body of rock salt extends under Central Kansas. Through it are being driven galleries 50 feet wide and 17 feet high. As the roof is good, no timber is needed; pillars 50 feet wide, cut off at every 80 feet by break-throughs, support the mine. The salt is under-cut to a depth of 3½ feet by pneumatic picks. Holes are drilled by augers working with compressed air—over twenty thousand holes being driven into the end of the working gallery. These are charged with dynamite, and fired by electricity. A slice of rock salt, seven feet high, is first removed; and at last the rest of the under-cut portion is brought down with dynamite in a broken mass of three thousand tons. Much of this rock salt is of coarse quality, and is employed for salting hides and making into alkalis and freezing mixtures. But more recently in Chile there has been discovered a bed of very pure salt that only requires grinding to convert it into a fine table variety. The mine is two hundred square miles in extent, and it contains salt sufficient to supply the entire world for several centuries. The nitrate works also produce, as a by-product, large quantities of salt. This, however, is not suitable for table use.

In many parts of the world, unknown mines of rock salt have for ages been used for making salt. In these cases, the hidden deposits are saturated with water that rises



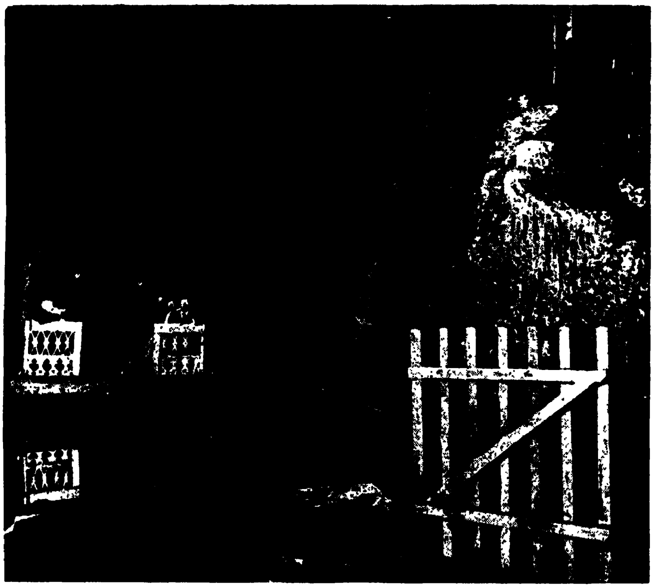
A BLIND PONY IN THE VIELICZKA SALT-MINE HAULING A LADEN CAR ALONG A RAILWAY



THE CHIEF SHAFT OF THE SALT-MINE OF SLANICU, IN ROUMANIA, BY WHICH EIGHTY THOUSAND TONS OF SALT ARE RAISED TO THE SURFACE EACH YEAR

towards the surface in the form of a brine spring. As the brine is often more salt than sea water the springs have, from the dawn of history, been the centre of some sort of manufacture. In England it is quite likely that the ancient Britons used the brine springs of Droitwich for making salt. It is certain that the industry was extending twelve hundred years ago; and since then many forests have been burnt to heat the pans in which the brine was boiled. So valuable were the Worcestershire salt-pits that there grew around them a primitive sort of joint-stock company, and people in Oxfordshire and Gloucester possessed shares in the undertaking. At the present time the pits at Droitwich and Stoke Prior produce 170,000 tons of salt a year.

The wells are about four feet in diameter, and are lined with sheet iron to prevent fresh water draining in. From the bottom of the well, hollow copper rods are pushed down until the brine is reached. It is pumped to the surface, and run into great brick reservoirs, and thence conveyed by pipes to salt-pans in various parts of the town. The average size of a Droitwich pan is 40 feet by 22 feet for fine salt, and 80 feet by 22 feet for coarse salt. The depth is about 18 inches. Huge fires are lighted beneath the pans to boil the brine, and after a time the salt forms a crust on the surface.



FERRYING ACROSS THE UNDERGROUND LAKE IN THE RUDOLF GROTTO IN THE VIELICZKA SALT-MINE

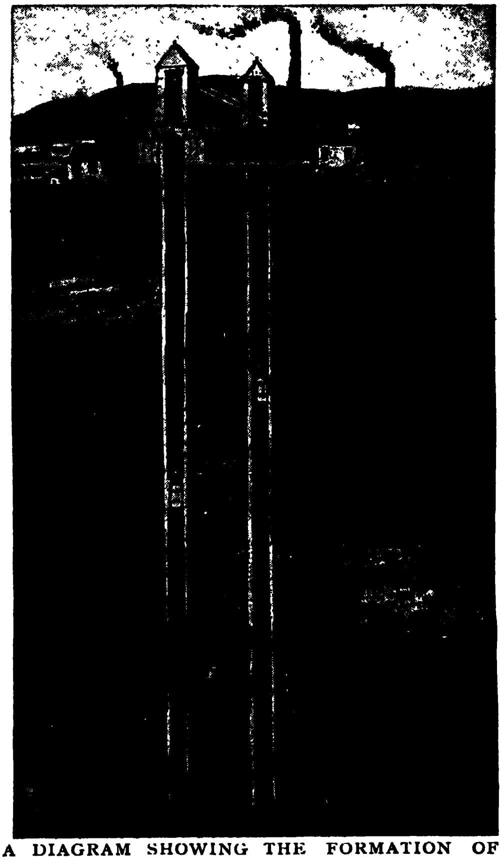
Droitwich, however, is now quite eclipsed by the Cheshire brine-pits in the valley of the Weaver. It is stated in the Doomsday Book that salt-springs were worked at all the "wiches" in Cheshire at the time of Edward the Confessor. It is sometimes said that every town ending in "wich" [illegible]ient centre of salt-making. [illegible]wever, only signifies a bay or [illegible] river—all places where, in [illegible]tances, salt could be made. [illegible]k that every "wich" in Saxon England was a Northwich or Nantwich.

As a matter of fact, the salt industry of Cheshire, and the alkali manufactures that depend upon it, are of fairly recent importance. The old brine springs were not ample enough to interfere with the making of sea salt along the coasts. It was not until the mine of rock salt near Northwich was discovered, in 1670, that Cheshire began to be one of the chief salt centres of the world. The discovery was made by accident, by some men who were engaged in exploring for coal.

The old Marston rock mine is the largest and the oldest in our country. For about a hundred years only its upper bed was worked, but in 1781 a deeper layer of rock salt was found beneath 10½ yards of clay. There are other deposits at a greater depth, but they are thin and impure. The total depth of the mine is 120 yards. At Winsford, where the same formation is seen, it is 150 yards from the surface. In the Northwich district the salt is first reached at a depth of from 35 to 40 yards, and the upper layer of rock salt is from 23 to 50 yards in thickness. Above it, and lying in the hollows of the bed, is a subterranean lake of brine. This is the brine which is pumped up to produce the fine, white Cheshire salt. The surface water trickles through the overlying strata of clays and marls, and dissolves the salt, and becomes heavy with the saline solution. In some countries the brine obtained from brine-springs is very impure and full of suspended matter. On being concentrated it turns brown in colour, and after yielding two or three crystallisations of salt it has to be poured away. Attempts have been made to get rid of the impurities by treating the brine with lime. When this is done, it certainly becomes clear and colourless on settling, but the dissolved lime retards evaporation.

and hinders the salt from crystallising. Our country owes its position in the salt and alkali industries to the fact that the British brines are both strong and pure. They are of a sea-green colour, and free from suspended matter, so less fuel is required to evaporate them. None of our springs now rises to the surface. In Cheshire, an iron pipe is placed in the boring, up which the heavy brine rises to a certain height. It is then pumped into reservoirs, at a sufficient elevation to feed the pans. Some of the very finest table-salt is now obtained from a bed of rock salt in Durham that lies at a depth of about 1000 feet. Special appliances are necessary to bring up the salt.

For, as the bed lies very far below, with an enormous mass of hard earth covering it, no surface water can trickle down to the salt deposit. The rock salt is about 100 feet thick, and it is reached by a bore-hole, ten inches in diameter, that goes down 1000 feet. For a short distance this bore-hole is lined with an iron tube; and inside it is a smaller pipe, from 4½ to 3½ inches in diameter, which extends right down to the bottom of the salt-bed. Thus between the bore-hole and the central pipe there is an annular space. Down this space all the water from the moist layers of earth trickles to the salt-bed. The water dissolves the salt, and then rises as a heavy brine in the inner tube, from which it is raised by a pump. From the pumps the brine passes to a large filter-bed. This is a clay-lined pond, filled with broken bricks and gravel and sand. From the filter bed the clarified brine runs into a brick-lined receiver, and from this it is sent, by an electrical pump, to large reservoirs built above the level of the evaporating-pans.



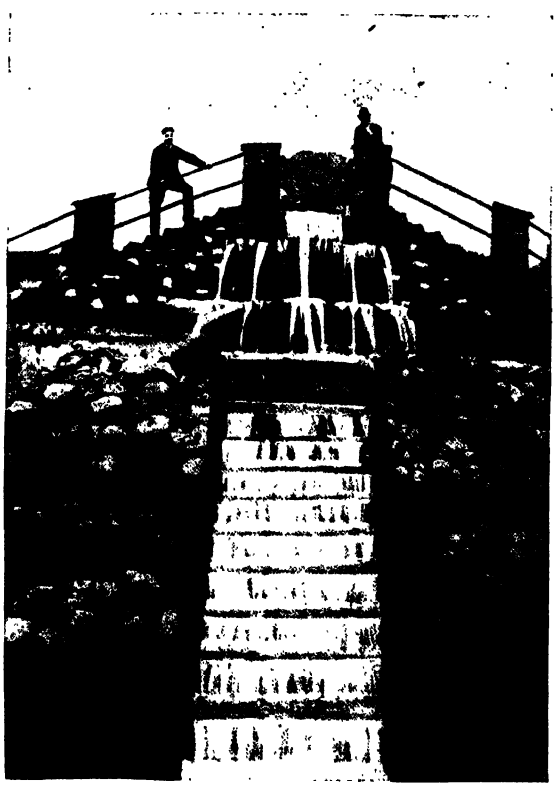
A DIAGRAM SHOWING THE FORMATION OF ROCK-SALT UNDERGROUND

The pans are made of sheet iron, and are about 60 feet long, 30 feet wide, and 3 feet deep. Beneath each pan is a set of four fires, the flues being carried back to the rear, and under a drying-stove. As the brine flows into the pan, it is heated by the fires to a gentle ebullition, and the salt separates in crystals, and falls to the bottom. As the mass of crystals accumulates, it is raked to one side of the pan. Then, with a skimmer—which is a long, shovel-like thing with a wide blade, perforated with many holes—the salt-maker lifts out the hot mass of small crystals, and pours it into the salt-tub. This is a wooden box, with holes at the bottom for the brine to drain through. It is hung on a bracket just inside the edge of the pan. Having filled the long line of thirty salt-tubs on one side of the pan, the salt-maker leaves them to drain, while he fills another set of tubs with the salt that has been accumulating on the other side. By the time this second task is finished, the salt in the first line of tubs has become dry and solid enough to be turned out of the tubs in the form of blocks. These blocks are put on a barrow, and wheeled into the drying-stove at the rear of the pan. Here the blocks are placed in the spaces between the flues, and piled up on the flues themselves, and allowed to stand for a week or more until they are well dried. Salt produced in this manner is formed of very small crystals. But it is not sufficiently fine for the best kind of modern table-salt. The finer the salt is, the greater is its strength. So now, when the blocks are dried, they are conveyed to a grinding-mill. An endless chain carries the blocks to the top of the grinding-machine, and drops them just behind a set of tooth rollers. The crushed salt falls from the rollers on to a set of oscillating sieves, that sift it into various degrees of fineness.

From the bottom of the machine, the salt

is drawn off into bags, weighed up into hundredweights, and stored for the last process of modern manufacture. This consists of mixing 4 per cent. of phosphates with salt ground to the uttermost degree of fineness. The phosphates used are—precipitated phosphate of lime, $2\frac{1}{2}$ per cent.; phosphate of soda, $\frac{3}{4}$ per cent.; and phosphate of magnesia, $\frac{3}{4}$ per cent. These phosphates are made from burnt bones, which, after being purified by fire, are washed with water. They not only add to the food value of the salt, but prevent the crystals from caking, and so preserve the fineness which is an important element of strength.

Early last year Mr. James Hodgkinson, an engineer of Salford, brought out an invention which is now revolutionising the manufacture of salt by artificial heat throughout the world. It is said that an American syndicate has paid the enormous sum of £1,000,000 for the American rights of Mr. Hodgkinson's patent. The inventor knew nothing whatever about salt-making, his energies being devoted to the improvement of a mechanical stoker suitable for feeding the various kinds of furnaces used in other great industries. But, chancing to visit some salt-works, he was surprised at the wasteful manner in which heat was used. No one had apparently thought of introducing modern engineering ideas into the salt trade. Mr. Hodgkinson saw a way of getting five or six times as much salt from a given amount of fuel; and he succeeded in doing this by using the waste steam and hot gases from one pan to heat the brine in other pans.



BRINE RUNNING INTO AN EVAPORATION CISTERN

His plant consists of about seven pans, all heated from one fire, regulated by a mechanical stoker that automatically secures a uniform feed and a constant temperature. As is well known, the quality of salt and the size of the crystals vary according to the temperature to which the brine is heated. Mr. Hodgkinson has succeeded in producing every quality of salt and every size of crystal simultaneously with one plant and one fire. In the first pan heated to a uniform temperature up to 1800 degrees, an exceptionally fine table-salt is produced, by a process of pure crystallisation. Then the waste gases and steam from this pan are employed in running the other pans. Steam is used to heat the brine as it enters the plant, thus hastening the precipitation of the crystals. At the same time, a power-driven fan creates an induced draught that does away with the necessity of a chimney, and saves the expense of heat needed to produce a natural draught. The stream of heated gases passes beneath the successive pans and the heat is regulated and controlled by dampers.

The second and third pans are arranged to produce dairy salt, which is slightly coarser than table-salt. The four other open pans that receive the gases at a much reduced temperature, produce the coarse salts used in preserving fish, and known as fishery salt. All the first three pans, in which fine salt is precipitated, are covered in, and have an automatic flow of brine and salt. To anyone acquainted with the economies now largely effected in heat-energy, the idea of Mr. Hodgkinson's invention may seem obvious. But salt-makers apparently lagged far behind the leaders of other industries, and Mr. Hodgkinson has won an enormous prize by bringing the salt-making plant up to date. We do not think, however, that his invention represents the ultimate stage of progress in the use of heat for boiling brine. Probably a still greater

economy could be effected by doing away with a coal fire, and putting the fuel into a gas-producer plant. The gas so obtained could then be mixed with the proper proportion of air, and injected into a fire-clay lining around the brine-pan, in the manner worked out by Professor Bone and Mr. McCourt. But, as we have already described the Bonecourt system of heat-production in POPULAR SCIENCE in another connection, we need not go into the matter again. The method of applying it to salt-making seems quite simple.

A serious disadvantage of the use of brine in salt-making is the harm done by the dissolving of the beds of rock salt in the depths of the earth. In ordinary mining, a great deal of timber is used to prop up the working passages; and in salt-mines massive pillars of salt are often left to support the galleries, as we have seen in the case of the mine of firm salt in Central Kansas. But in the brine-well system the rock salt is gradually dissolved away by the fresh surface water that trickles down to the salt. Every year in Great Britain a square mile of salt, a foot in thickness, is removed at a great depth in the earth. As this is chiefly done by water, it is impossible to support the ground above the dissolving bed of rock salt. So the soil above caves in on the empty space and produces a miniature earthquake. The beginning of such a subsidence is shown in the top picture on page 4114.

In the chief salt districts of Cheshire, scarcely a house or chimney-stack now remains straight, and many buildings are only kept from falling by leaning against each other. Doors and windows have lost their original shape, and look like caricatures of human handiwork; the floors climb up and down in nightmarish fashion, and the walls bulge as with sinister intention. Some buildings vanish altogether. Lakes ripple in the breeze where there was solid ground, and even these stretches of water will sometimes fall through a crack in the earth, and drain into a subterranean cavern that was once a mass of rock salt. An incalculable amount of damage has been done to property around the Cheshire brine-pits, but the subsidences cannot be prevented, without putting an end to an important national industry.

FIRING THE FURNACES BENEATH THE BRINE-PANS FROM WHICH SALT IS COLLECTED—A METHOD THAT IS NOW BEING SUPERSEDED IN THE MOST UP-TO-DATE SALTWORKS

The Russians possess a much more convenient source of salt in their salt lakes, and they now have a larger output than British salt-makers. The United States comes first and Russia next, while Germany and our country struggle for the third position. The great German salt-mine at

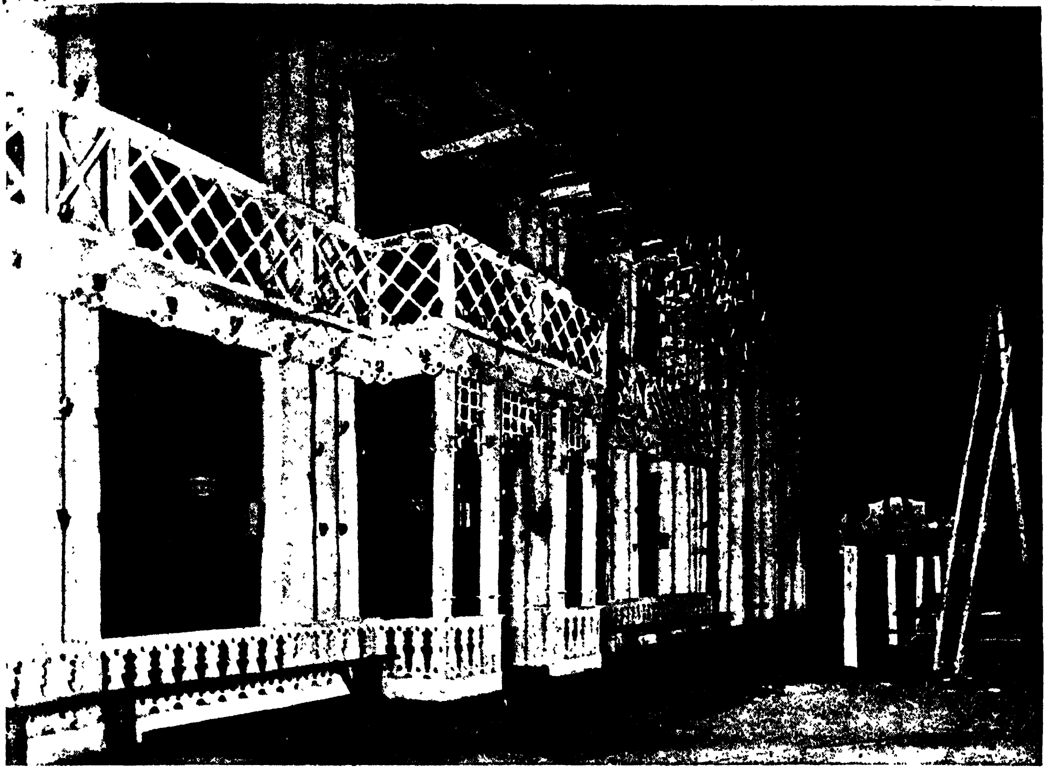
Stassfurt is now one of the most profitable centres of industry in the world. Its extraordinary development is a business romance of the nineteenth century. In 1839, its owners tried to increase their production by making some borings in search of rock salt. But the brine they obtained was so charged with salts of potassium that the boring was abandoned. In 1860, however, the superintendent of the mine had an idea of finding some use for the waste potassium. By patient research he discovered its composition, and at the same time the owners of the mine found it possessed a high fertilising value. So in 1861 the first factory for the manufacture of potassium was installed at Stassfurt. So important has potassium now become that it is largely under the control of the Government. The output is about £5,500,000 worth of material a year; and the common-salt production of the mine has shrunk into comparative unimportance.

By utilising what were once the disastrous impurities of Stassfurt salt, the Germans now absolutely control the potash industries of the world. A few years ago, some American manufacturers of fertilisers acquired a right in some German mines, with a view to obtaining cheaper supplies of the principal material of their business. The German Government replied by passing a law regulating the price of potash, and forbidding anybody in Germany from selling under the price. The United States Government tried to interfere, and protect American interests, but the Germans would not give way, and they defeated the attack on their monopoly. They are now trying to absorb more of their own potash in their farming operations, and thus enable German agriculture to reap most of the advantage of the strange discovery at the Stassfurt salt-mines.

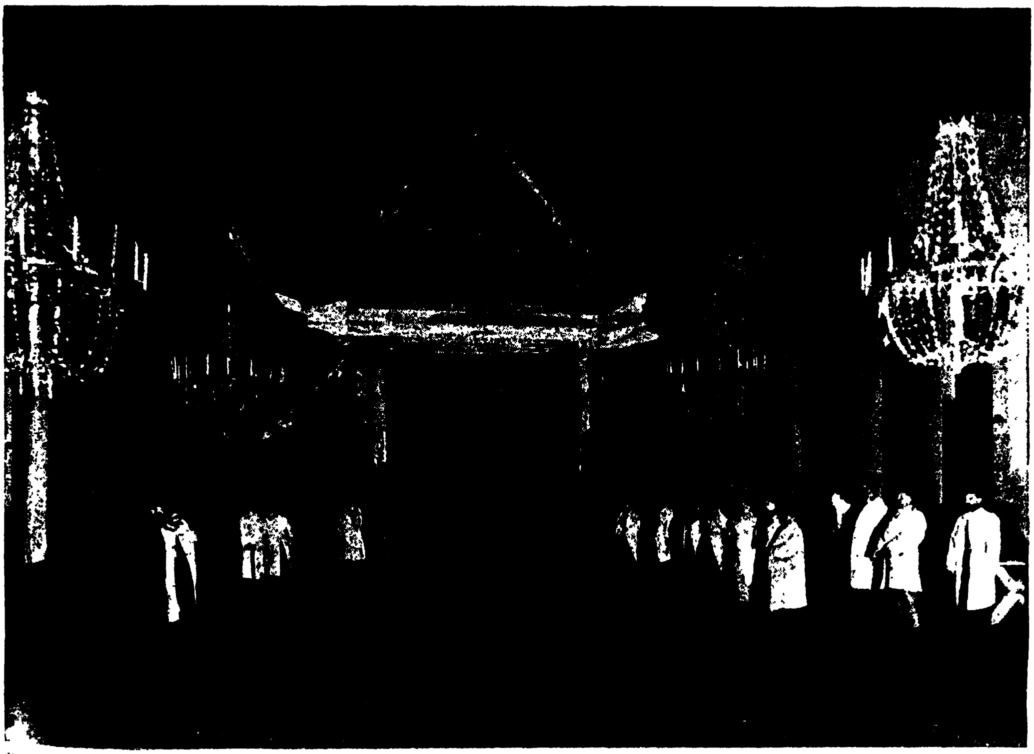
In our country, the brine-pits and salt-mines provide the material for the most important of our chemical industries. As we have explained, common salt consists of sodium and chloride. So the compound of sodium in common use—soda—can be obtained by splitting up salt, and combining its sodium with carbon. This used generally to be done by treating salt with oil of vitriol, according to a method invented by the Frenchman Leblanc. But two English chemists, Dyar and Hemming, worked out a new process in which ammonia was used, and the ammonia-soda process was developed by a Belgian salt-maker, Ernest Solvay, and introduced into this country again by the late Dr. Ludwig Mond. It was in the early 'seventies that Dr. Mond embarked his little capital in acquiring the English rights in the Solvay process. He was joined by his friend Mr. J. T. Brunner, and the

DRAWING THE COMMON SALT USED IN FISH-CURING AND OTHER INDUSTRIES, WHICH HAS SETTLED AT THE BOTTOM OF A BRINE-PAN

SCENES IN AN UNDERGROUND TOWN



THE RAILWAY STATION DEEP DOWN IN THE GREAT SALT MINE OF VIELICZKA



THE BALLROOM IN THE SALT MINE, WHERE THE UNDERGROUND FAMILIES TAKE RECREATION

two partners erected their works over the Cheshire salt deposits.

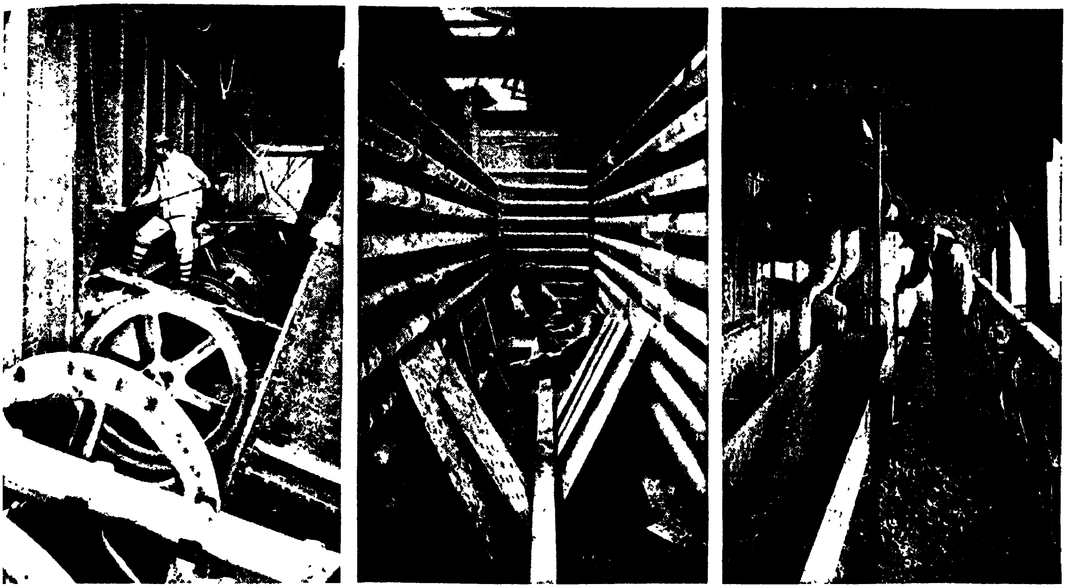
At this time, however, Solvay's process was very far from perfection, and Messrs. Brunner, Mond, and Co. had a very anxious and wearing time for the first twelve months. For at their works everything that could explode exploded, and everything that could break broke. At the end of a year the partners had little left except their credit and their English licence. But, by the genius and inventive skill of Dr. Mond—who was a pupil of the famous German man of science Bunsen—the ammonia-soda process was gradually improved, until the manufacturers who kept to the Leblanc method were very hard put to it to compete with the more scientific production of soda. Indeed, the Leblanc process would have gone out of use had it not been for the by-product of chlorine. This, in the form of hydrochloric acid used for making bleaching-powders, became more important than the soda, and helped to make up the loss on the main product.

The reason for this was that the Leblanc process wasted its sulphur, and the ammonia-soda process wasted its chlorine. Dr. Mond made repeated efforts to remove the blot on the cycle of operations, but the economic production of bleaching-powder from an ammonia-soda plant under existing conditions is a problem that still awaits solution by the scientist.

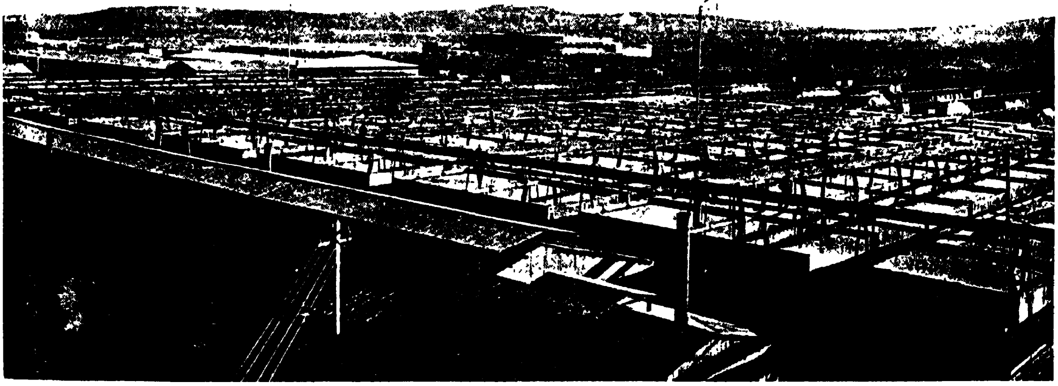
In the meantime, both the rival processes are menaced by a new electrical method of splitting common salt immediately into sodium and chloride. A few years ago Mr James Hargreaves and Mr. Thomas Bird started a small electrical plant at Middlewich, in Cheshire, over an underground lake of salt. The brine was pumped to the surface, and conducted into rectangular chambers, through which a strong current of electricity was passed. The effect of this was to liberate the chloride. It escaped in the form of gas, and was led through pipes into a chamber filled with lime, where it formed chloride of lime, or bleaching-powder. The solution of sodium was treated with a bath of steam, and converted into a soda solution. By a very simple arrangement in the construction of the chambers, the carbonic acid gas, issuing as a waste fume from the furnaces which supplied the power, met the soda solution, and turned it into a

BRINGING THE SALT DRAWN FROM THE PANS INTO THE WAREHOUSE

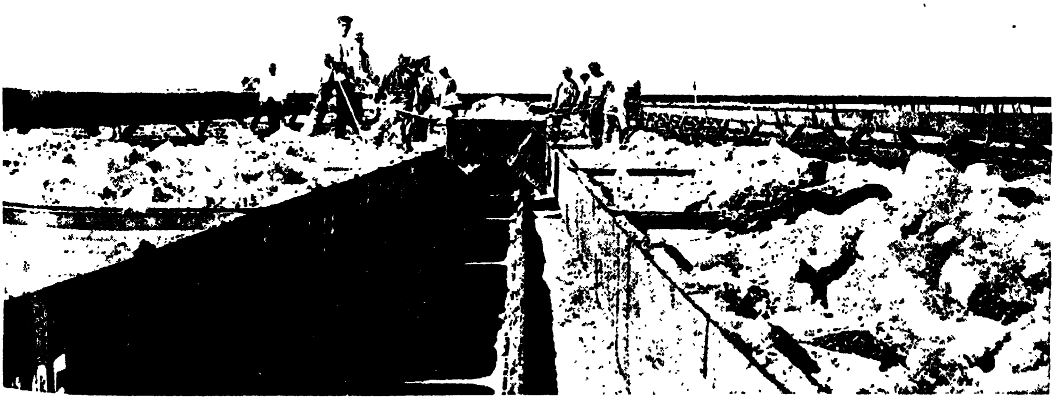
THE GREAT CHILIAN NITRATE WORKS



THE CRUSHING PLANT, BOILING-TANKS, AND SATURATED SOLUTION POURING FROM THEM



THE PANS IN WHICH THE SATURATED SOLUTION IS RECRYSTALLISED

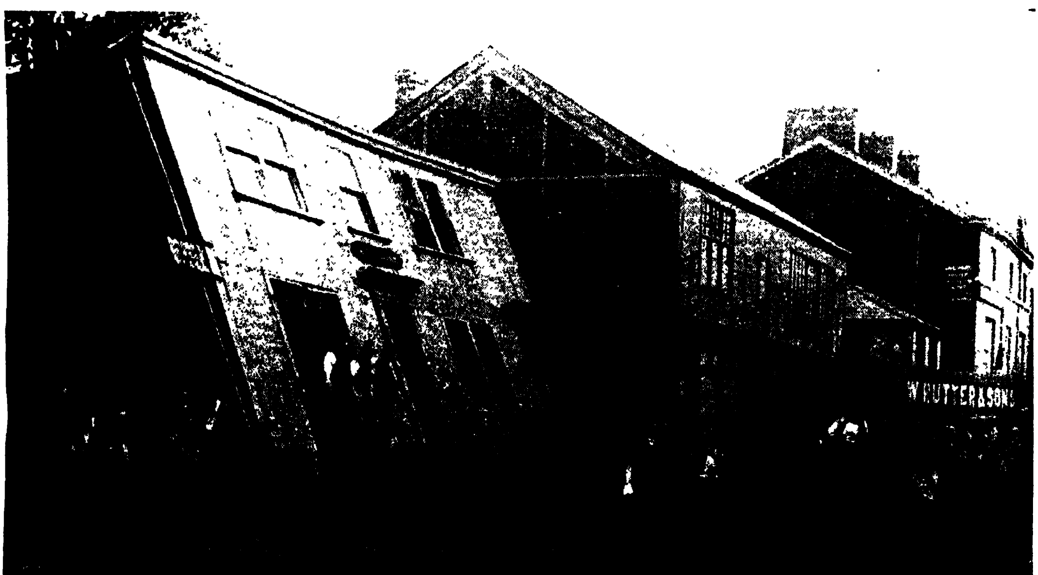


LOADING CARS FROM THE CRYSTALLISING-PANS OUTSIDE THE FACTORY

THE BEGINNING OF A GREAT SUBSIDENCE ON THE OUTSKIRTS OF NORTHWICH

solution of carbonate of soda. This was then thrown into vats, where the soda hardened into crystals.

This direct and simple method of breaking salt up into its two valuable elements has now proved to be a commercial success. And everything that cheapens the production of electrical power now cheapens the manufacture of soda and bleaching-powder. As the spent fume from the coal furnace supplies the carbon needed to form carbonate of soda, the electrical process is likely to flourish in a country like ours, possessing as it does abundant supplies of both coal and salt. The Leblanc process is seriously menaced by the electrical method; indeed, it is not expected to survive the struggle with its new competitor. In the ammonia-soda process, there is a greater economy of production, especially in the use of fuel, but in actual practice even this ingeniously developed method of manufacturing alkali has some serious imperfections. So it is not improbable that the electrical dissolution of common salt will become the supreme process in soda and chloride manufacture, and greatly benefit the consumer.



THE SUBSIDENCE OF A SOLICITOR'S OFFICE AT NORTHWICH

METHODS OF WORLD-TRADE

The Permanent and the Transitory Causes of Commerce Between Nations

WHAT IS MEANT BY A "BILL ON LONDON"

In earlier days of economic thought, as for example when John Stuart Mill wrote his "Principles of Political Economy," it was of some use to distinguish the character of "international" from that of "domestic" trade. It was then customary to base argument and theory upon the supposition that capital and labour were alike immobile as between country and country. Today, at the end of the first decade of the twentieth century, both capital and labour, and especially the former, have become exceedingly mobile, and often flow readily from one part of the world to another—sometimes even more readily than within the boundaries of the same country. Writing in 1848, Mill said, "If capital removed to remote parts of the world as readily, and for as small an inducement, as it moves to another quarter of the same town; if people would transport their manufactories to America or China whenever they could save a small percentage in their expenses by it, profits would be alike (or equivalent) all over the world, and all things would be produced in the places where the same labour and capital would produce them in greatest quantity and of best quality. A tendency may, even now (1848), be observed towards such a state of things; capital is becoming more and more cosmopolitan; there is so much greater similarity of manners and institutions than formerly, and so much less alienation of feeling, among the more civilised countries, that both population and capital now move from one of those countries to another on much less temptation than heretofore."

In the years that have elapsed the tendency of which Mill spoke has become pronounced. We live in times when the savings of a country may be made even more largely out of a country than within its borders. The migration, not only of capital, but of capitalists, over border-lines is also remarkable. We find American firms establishing themselves in the United Kingdom; British firms setting up works in Russia or in America; German firms erecting factories in Italy or in England. As to labour, it is true of many great countries that there is a larger amount of migration over their boundary lines than within them in any recent year. It is rarely that a man of Lancashire transplants himself to Devonshire, or that a man of Wiltshire moves to Norfolk—we speak not of the upper or middle classes, of course, but of the working classes. But from Lancashire, from Devonshire, from Wiltshire, and from Norfolk alike, and indeed from every part of the United Kingdom, we find working men, who would not readily move about their own country, emigrating over the boundary line to Canada or Australia or the United States of America. There can be no question that we are rapidly tending towards a condition of trade in which, to use the words of Mill, all things will be "produced in the places where the same labour and capital will produce them in greatest quantity and of best quality."

Under these conditions it is not necessary or helpful to consider the construction of any separate theory of international trading. There is no real distinction between the causes of the exchange of products between two or more persons in England and France, and two or more persons in Middlesex and Lancashire. There are often more impediments in the way of foreign than of domestic trade, of course. The fact that the British trader and the French trader speak different languages, have different customs and habits, use different coinages, and are separated not only by distance but by sea, amounts to the existence of a number of more or less serious barriers to intercourse

or trade. It must be observed, however, that these barriers are by no means peculiar to international trade as distinguished from domestic trade. For example, trade between Canada and the United States is "international," but it is conducted by persons who speak the same language, who are accustomed to the same forms of currency, whose habits and customs are very similar, and who are in intimate connection by land in many districts. There can be no question that trade between Ireland and England encounters more serious barriers than trade between persons in the north-east corner of the United States and persons in the south-east corner of Canada.

It is true that artificial barriers are erected between nations by the imposition of Customs duties by their Governments, but even these are by no means peculiar to international trade. Octroi duties, or internal Customs barriers, still exist within the boundaries of some countries, and their effect upon the trade of localities is precisely similar to that of international Customs duties.

The Conditions of International and Individual Trade the Same

From our studies of trade in practice in earlier chapters we find no difficulty in perceiving the conditions which give rise to international trade. It is clear that trade between individuals, whether those individuals are citizens of the same country or citizens of different countries, finds its basis in differences of kind or of degree of powers of production. For example, if Smith can make hats better than boots, while Brown makes boots better than hats, it is obvious that it will be well for Smith to stick to hatmaking while Brown sticks to bootmaking, and for Smith to exchange his hats for Brown's boots. Here we have the simplest possible basis for international trade, as it is also the simplest possible basis for domestic trade.

Now let us suppose that Smith can make both hats and boots better than Brown. Is there *then* any good basis between them for trade, or the exchange of goods? The answer is that there may be. If Smith can make hats four times as well as Brown, and boots twice as well as Brown, it would pay both Smith and Brown to divide the trades between them, so that Smith did all the hatmaking and Brown all the bootmaking. A moment's thought will show that, by that means, each would get better value for his labour than if each made hats and boots. Ricardo pointed this out in the following passage. "Two men can make both shoes and hats, and one is superior to the other in both employments; but in making hats he can only exceed his competitor by one-fifth, or 20 per cent., and in making shoes he can excel him by one-third, or 33 per. cent Will it not be for the interest of both that the superior man should employ himself exclusively in making shoes, and the inferior man in making hats?" The one man is better than the other in both occupations, but it is a common-sense arrangement that he should confine himself to that occupation in which his advantage is supreme.

Natural Advantages Make Ultimate Differences Between Nation and Nation

Applying these important considerations to international trade, we see that, as regards a very considerable number of trades, the individuals of one country possess over those of another, or of others an advantage afforded by Nature. We do not refer here to differences of individual or race genius, but to differences founded on natural opportunity. The good things of the world are most unevenly distributed; and although the fact should be obvious to the most careless of observers, it is most necessary to refer to it, and to insist upon it, because nothing is commoner than utterances and writings which show that what ought to be so obvious has been completely overlooked or ignored. It is, of course, only natural that the speaker or writer of any particular nation should attribute its wealth, or superior position in production or trade, to native genius, and not to native gifts. That is a very human reason for the ignoring of the importance of natural opportunity; we all like to believe that not good fortune but our own natural superiority or talent has given us whatever advantages we possess.

A Comparison of the Natural Advantages of England and Italy

Another frequently occurring reason for ignoring natural gifts is that those who favour some particular policy or change of policy, anxious to make the best of their case, point to what has been done in their own country, or to what has been accomplished in other countries, as a reason for either adhering to a particular course or for changing that course, as the case may be.

In the light of reason, however, we see that the principal motive for international trade, at any rate between the white races, is the very unequal degree in which Nature has conferred her gifts upon different

countries. Perhaps, as between the civilised countries, no more striking illustration of this fact can be given than the difference between England and Italy. England, with its fitful sunshine, can only grow the vine with effect in hothouses; and although wine made from hothouse grapes might be a very delectable product, it certainly could not come to form an item of any importance, either in domestic trade or in international trade. There is thus a permanent and almost unalterable basis for the importation of wine into England. On the other hand, Italy is, for practical purposes, coal-less, and consequently it is almost impossible for her to smelt iron on an economic basis. As a result, there is a stable reason for the importation of coal into Italy. We see that the respective citizens of England and Italy, as long as present conditions last, have a permanent reason for exchanging those two exceedingly dissimilar products, wine and coal.

The Disparities in Natural Advantages Between Country and Country

We have only to think over the extraordinary variation of natural products which we studied in detail in earlier chapters to see how few countries produce coal in large quantities; how the various metals – iron, copper, lead, tin, zinc, etc—are found largely in some countries, and little, or even not at all, in others; how some have wide, fertile, and well-watered areas, where agricultural produce can be very cheaply raised, while others, if they devote themselves to agriculture, have to prosecute it by exceedingly arduous toil. We know that climate is an insuperable barrier to the raising of some products in all countries. Doubtless science will make such further considerable progress in the twentieth century as to equalise some of these conditions, but it can never abolish some of the most striking dissimilarities of gift. The permanent basis of trade found in differences of natural opportunity, therefore, will remain, and, indeed, increase, as the barriers to trade are pulled down by invention. We have, of course, not seen the last of the development of the means of communication, and the men of the next century will probably deem our present methods of transport ridiculously inadequate.

Differences in ability are as " natural " as differences of material gift; and it by no means necessarily follows, because a nation is well gifted in land or fertility, or raw materials, or geographical position, or ports, that it will occupy a high place in the world of trade. We have a most striking illustration of this fact in China, which, as we saw in Chapter 5, has some of the finest coal in the world, combined with other mineral resources of unequalled wealth. So far, however, China has put her coal resources to very little account, although her people used them in small degree many centuries ago, as recounted by Marco Polo

The Gifts of Nature of Small Account Without the Gift of Ability

Even more striking, perhaps, was the picture that existed not long ago of tribes of Indians living lives of extreme poverty, and sometimes perishing of want, although inhabiting what we now realise to be one of the most naturally gifted lands in the world—North America.

If we confine our considerations to the white races, we see extreme dissimilarities of race genius—dissimilarities which will for ever continue to be the springs of trade between nations. Fortunately, men are so constituted that they can ardently admire qualities which they do not themselves possess. Just as the man who has no gift of eloquence can sit entranced by an orator, so the people of a nation who are not gifted in a certain art may, none the less, admire it, and be eager to become the possessors of its products. This important factor in trade is not only permanent but likely to increase as culture grows amongst the races of the world. There will undoubtedly be a greatly enlarged international trade in artistic productions, to the general good of all sorts and conditions of men.

Trade Determined Largely by the Amount of Land a Nation Possesses

Differences of ability or of genius combine with differences of material gifts to form causes of trade, but it is not infrequent to find two trading nations each able to produce in some degree every sort of commodity exchanged between them. The exchanges take place, nevertheless, just as we saw in our hypothetical case of Smith and Brown, and the hats and boots. Remembering that nations are aggregations of individuals, we can readily understand that relative advantages may play as deciding a part in the trade between two nations as in our case of Smith and Brown.

The respective amounts of land which two nations possess may also largely determine the condition of trade between them. The United Kingdom is a country with a small area and fine coalfields. She can support, by reason of her industry based upon her coalfields, an enormous population engaged

in industry; and in view of the fact that she has such great natural advantages in large-scale production, it is her obvious interest to be a manufacturing nation. In practice she has found that her energies have naturally turned to manufacturing, although many of her citizens today do not understand why. If we turn to Canada, on the other hand, we find a country of enormous area, with great spaces of fertile soil which, with the application of little capital and labour, can produce enormous and cheap supplies of food. Between Britain and Canada, or between Britain and Argentina, or between any other two countries with such dissimilarity of gift in point of land, there is thus a natural basis for the exchange of products.

Roughly, the division in this respect is as between "Old" countries and "New" countries. In England, or Scotland, or Germany, or France, or Belgium, a large amount of arduous toil is required to raise a certain amount of food. In Canada, or Argentina, or the United States, or Uruguay, or Brazil, or Australia, the same amount of labour applied to the large available areas of virgin soil will produce a much larger amount of food. Under conditions of free competition, therefore, now that sea-freights are so much lower than they used to be, it becomes very difficult for the cultivators of the "Old" countries to hold their own against the cultivators of the "New," and it is for that reason that some countries, such as Germany, deliberately adopt a protective policy for their agricultural workers, believing it to be in the national interest to raise the price of food above what it is in "New" countries, in order to preserve agricultural industry, even at the cost of the manufacturing part of the population.

Reflection will show that in the long run the conditions of food production will be equalised, save in respect of climate, in all parts of the world. That is to say, under similar conditions of climate, it will eventually require the same amount of labour to produce a given amount of food in any country or latitude. But that time will be long delayed because of the enormous area of virgin soil which exists yet untilled in the world. The matter can have only one end, but we do not know when that end will be; it will depend upon the volume of emigration from the Old World to the New, and also upon the progress of science in its application to agriculture.

It is, however, very necessary to observe the changes in the position of countries in this important respect—changes which are taking place with bewildering rapidity. Take the case of the United States, for example. Not long since she had what appeared to be almost illimitable areas of forest; in 1912 they have been so far denuded that some varieties of timber are quite scarce within her borders. Similarly, large portions of her virgin soil have been robbed of their native fertility by repeated cropping without manuring, and left deserted. Let us see what changes have occurred in American exports of food in recent years. Here is an account of the chief foodstuffs exported from America.

VARIATION IN AMERICAN EXPORTS OF FOODS

1901—1911

Food	1901	1911
	Dollars	Dollars
ANIMALS:		
Cattle	37,567,000	13,164,000
Hogs	238,000	74,000
Sheep	1,933,000	636,000
BREADSTUFFS:		
Wheat	96,772,000	22,040,000
„ Flour	69,459,000	49,387,000
Indian Corn	82,528,000	35,961,000
„ Meal	2,065,000	1,457,000
Oats	11,765,000	833,000
„ Meal	2,309,000	1,044,000
Rye	1,322,000	2,000
FISH:		
Cod, haddock, hake, etc.	346,000	111,000
Salmon, canned ..	4,230,000	4,037,000
MEAT:		
Beef, canned	5,307,000	1,255,000
„ fresh	31,851,000	4,478,000
Bacon	37,499,000	21,212,000
Ham	22,843,000	20,709,000
Pork, canned	708,000	481,000
„ fresh	2,424,000	160,000
„ pickled	9,927,000	4,944,000
Mutton	47,000	219,000
DAIRY PRODUCE:		
Butter	4,015,000	1,050,000
Cheese	3,951,000	1,288,000

Some of these details can only be described as astonishing, and they call for our closest attention. They help us to understand why food has grown dearer throughout the world during the last fifteen, and especially during the last ten, years. Here we have a country which, not long ago, was an enormous exporter of breadstuffs, meats, and dairy produce. At one time we could depend upon America for an enormous proportion of the wheat

we do not produce for ourselves; today we have to look to other "New" countries. Taking all breadstuffs together, including those shown in the above table, and others, in 1901 the exports from the United States were worth 276,000,000 dollars; in 1911 they were worth only 125,000,000 dollars.

With regard to meat and dairy products, some of the changes in the ten years have been startling. In 1901 the United States exported 2,400,000 dollars' worth of fresh pork; in 1911 the export was only 160,000 dollars—an almost negligible quantity. Of fresh beef, the American export in 1901 was 32,000,000 dollars; in 1911 it had sunk to 4,500,000 dollars. We see drawing nearer and nearer the time when the United States will either have considerably to improve her agricultural methods or else become dependent upon foreign food, as her population rapidly increases through natural increase and immigration combined.

It will be gathered from this change in the character of the United States' food exports in only ten years how difficult it is to form any intelligent estimate of what the trade of the world will be like in fifty or even twenty-five years' time. We can describe the nature of the principal factors that are at work; we do not know *how rapidly those causes will operate.* It does appear, however, that we are at the beginning of an era of unprecedentedly rapid development; and it is, more than ever before, the duty of the intelligent citizen of the world to keep himself informed of the wonderful changes which are taking place. It is not now safe to depend upon conceptions of magnitude formed only a few years ago. If we desire to be accurate, it has become absolutely necessary to consult the very latest returns from any of the great countries, before committing ourselves to a statement as to the degree or kind of its commerce.

There was a time when a great deal of international trade found its origin in the fact that certain countries had much better supplies of trade capital than other countries. This cause is rapidly disappearing, owing to the extreme facility with which capital passes from one country to another in these later years. We can form a conception of the great rapidity with which British citizens are making investments in foreign countries from a return of that part of the interest from foreign investments which is noted by the Inland Revenue Commissioners in their annual reports. Here are the returns for the last eleven years.

INCOME RECEIVED IN UNITED KINGDOM FROM ABROAD

(As noted by Inland Revenue Commissioners)

1900—1911

Year	Gross Income
	£
1900–01	60,332,000
1901–02	62,559,000
1902–03	63,829,000
1903–04	65,865,000
1904–05	66,062,000
1905–06	73,899,000
1906–07	79,560,000
1907–08	85,116,000
1908–09	88,837,000
1909–10	93,264,000
1910–11	100,953,000

It should be remembered that this table does not give a complete account of all the interest received in the United Kingdom from foreign investments; it refers only to such part of it as can be recognised as such. Nevertheless, it gives us an accurate picture of the rate of increase; and we see that this known part has increased from £60,000,000 in 1900-1, to £101,000,000 in 1910-11. But not only this country is engaged in feeding other lands with capital. France, Germany, and the United States are playing a great part in the capital development of other lands.

There was a time, of course, when Britain was the only country which had capital dealings on a large scale, and when British investment in trading concerns abroad was almost negligible, the chief part of our foreign investing being in Government loans. That meant, of course, that manufacturing in the United Kingdom had a great advantage as compared with manufacturing in countries which lacked capital. Today this relative advantage has disappeared, and this particular cause of international trade has weakened.

Perhaps we may truly sum up all the considerations involved by saying that, in the long run, production in the world must come to be carried on in those places best fitted by Nature for the task, by those races which have, either through inherent ability or acquired skill, become best fitted to work in them, and that commerce will flow accordingly between individuals, and that the nature and degree of commerce will accordingly be determined. It is already clear that very great changes will take place in the nature and degree of commerce, changes which will not surprise those who

realise that even in the last 150 years the nature and degree of the commerce of Britain has been revolutionised.

International trade is set up in many other ways than by the exchange of goods between persons in different countries. The fact upon which we have just dwelt, that large amounts of capital are invested in other countries by British and foreign investors, is in itself a cause of commerce.

Investment of Capital in Foreign Countries a Cause of Commerce

Let us think what takes place when a foreign or Colonial investment is made by a person domiciled in Britain. Let us first imagine that the investor is a person who has not already any foreign investments, and who is investing money which he has gained by trade or investment in the United Kingdom. He subscribes, let us say, part of the capital of a new railway to be constructed in Brazil. What actually happens is that the Brazilian undertaking draws from the United Kingdom *not money or gold, but goods.* It requires rails, locomotives, etc., for the plant of its railway, and it imports these from the United Kingdom, or from some third country to which the United Kingdom exports. Thus essentially the investment in Brazil means the exportation of goods from the United Kingdom. The investment is thus the cause of the flow of commerce. What happens thereafter? The answer is that several different things may happen. The company may fail, in which case the investor will get no return for his investment, and that will mean that no imports will be received by the United Kingdom as interest upon the investment.

How Interest Takes the Form of a Flow of Exports

If the investment is a good one, however, as has usually been the case with South American railways, interest will be periodically received by our English investor, which means that money will be placed to his credit at his banker's, which he will utilise at his need. In essence, the payment of the interest by the Brazilian railway company to the person in the United Kingdom will take shape in the form of *Brazilian exports of goods to the United Kingdom,* or to some other country from which the United Kingdom imports.

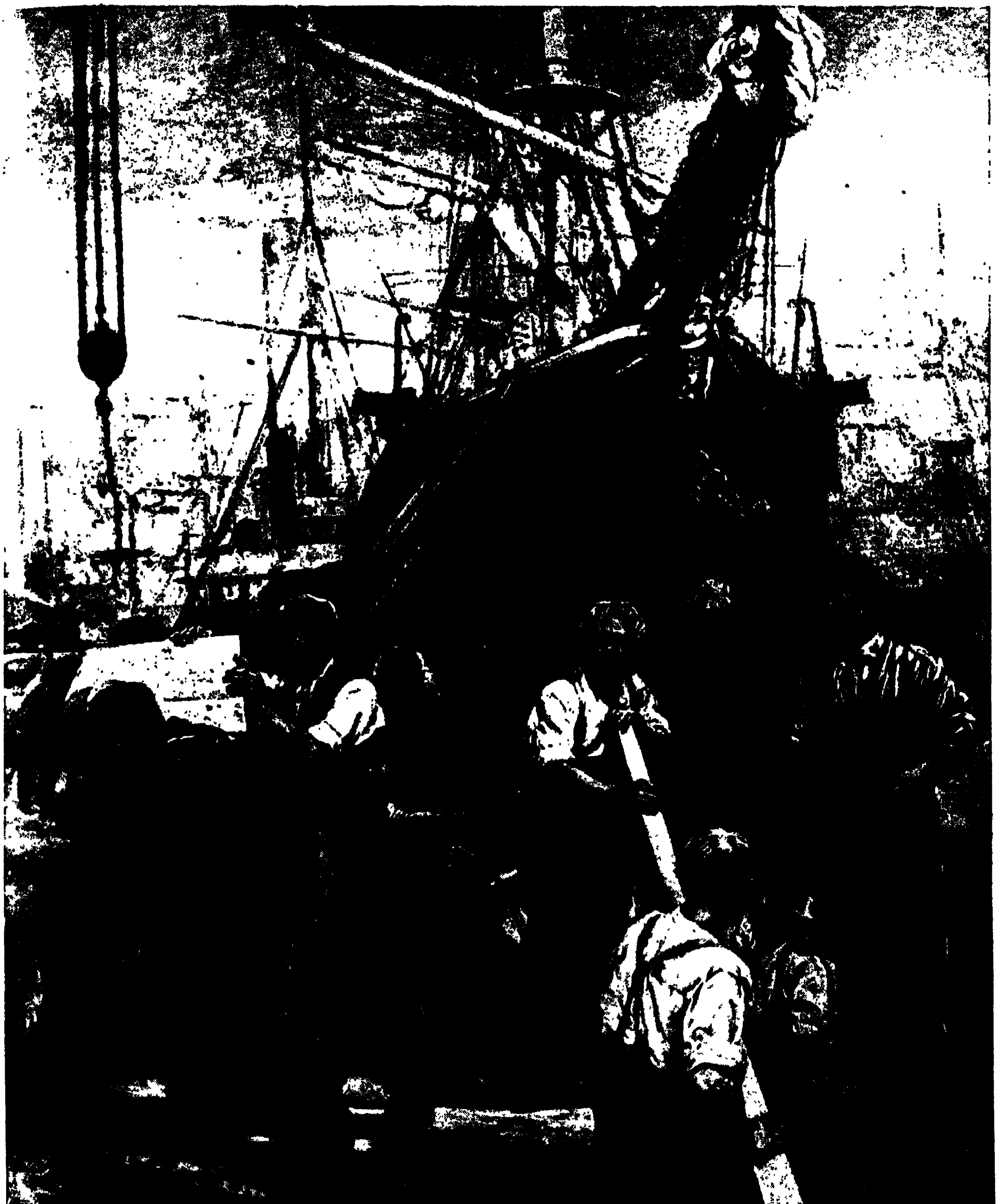
So we see a lump sum of exported goods going out of the country as an "investment," and drawing a periodical return of imported goods as "interest." It will appear from this simple and common example of what actually takes place that it may easily happen that a country may receive more goods in imports than it exports. For, if the company pays 10 per cent., and the amount of the investment is £1000, Brazil will, in the space of twelve years, send to the United Kingdom goods worth £1200; whereas it received originally from the United Kingdom goods worth only £1000, and even then, of course, the original £1000 will still be owing.

A very common case of this kind in recent years has been the fortunate rubber investments made by many investors. Some of the best rubber companies have paid dividends of over 100 per cent., or even 200 per cent., per annum, which means in essence that the United Kingdom has exported goods worth so much, and in the course of a few years has received, as interest, imports worth many times more than the exports of capital in respect of which they are paid.

The Flow of Goods from Country to Country Directed by Investments

It will be seen how complex the relations of trading nations become through this making of investments and payment of interest. A further complication will be readily understood. Referring again to the hypothetical case of a British investment in a Brazilian railway, after some years the British investor may sell his stock, and that stock may be bought by a rich Brazilian domiciled in Brazil. If that takes place, the £1000, or whatever the selling price is, will be remitted by Brazil to England, which means that *goods will be sent by Brazil to England.* Thereafter, the British investment having ceased, the periodic flow of goods as interest will cease.

In the example quoted, we assumed that the British investor was not already an investor abroad. Let us suppose, however, that he is one who has already large investments abroad, and that in 1912 he has £1000 worth of interest due, and payable, on his existing foreign investments. Instead of spending it, he invests this £1000 in another foreign investment. In that case, British goods will not go out as an investment, but in essence what will happen will be that the investor will not draw from abroad £1000 of imports which he might draw, and he will, in effect, direct them to be supplied to the undertaking in which he makes his new investment. For this reason, it is not always true that a new oversea investment means necessarily an exportation of goods from the country of the person who makes the investment. Here is another source of



THE GOLDEN ARGOSIES OF COMMERCE—FROM THE PAINTING BY MR. B. F. GRIBBLE

complication in international commercial exchanges.

The flow of goods from one country to another may also be caused by the necessity to pay for services rendered. London is the chief money market of the world, and it is common in international dealings to draw a bill of exchange upon London as a means of payment. A "bill on London," or "sterling bill," as it is called, is recognised international currency, and it has come about that London has become a Clearing House for international debts. This means, of course, profit for London bankers, and the profits so made are drawn into the United Kingdom in the form of imports of

goods. Thus, without any goods going out of the United Kingdom, goods become due and payable to the United Kingdom, and another complexity is added to the causes of our commerce in goods.

A fact of even greater importance in international trade is the rendering of services in carrying goods. If a ship of country A carries goods for a citizen of country B, there will have to be a remittance from B to A, which will, in the absence of similar services rendered in the other direction, have to be satisfied by an exportation of goods from country B to country A. It follows that the countries which possess great mercantile marines receive payment by goods for the services they render. Chief amongst these, of course, is the United Kingdom, which, as we saw in an earlier chapter, owns more than one half of the effective sea-going tonnage of all the world. Britain is thus not only an international banker, but an international carrier, and she receives enormous quantities of goods every year in payment for the service of her ships.

Still another cause of trade other than the exchange of actual goods has to be noticed. It is the fact that travellers going to a foreign country take with them spending power; in effect, what happens is that goods are exported from their own country to the country in which they travel in order to satisfy the expenditure they make in the foreign country. The individual, of course, is not actually concerned with what takes place. He takes his bit of paper from his banker—his letter of credit—and in the country to which he goes he obtains the cash of the country to spend as he wants it. The ultimate satisfaction of the transaction, however, is the flow of goods from the one country to the other.

It will readily be seen that for any particular country there is, in any particular year, a combination of all these complexities. Its citizens sell goods abroad, and buy goods from abroad; they invest abroad, and receive investments from abroad; they receive interest from abroad, or pay interest to persons abroad; they render services to persons abroad by shipping or banking, etc., or have such services rendered to them by persons abroad. For each country the combination of these various factors works out to a different result in point of the actual goods exported or imported. Some countries send out more actual goods than they receive; others receive more goods than they send out. On page 4123 is an account of the actual facts as to the importation and exportation of goods by certain countries in 1910; it is a most illuminating table of commerce to one who understands, while to the uninitiated it spells mystery and bewilderment.

The two countries at the head of the table afford a curious contrast. The United Kingdom, having many foreign investments, being the great international banker, and possessing a magnificent mercantile marine, has, of course, a great excess of imports of goods received by her in payment. The United States, possessing few ships, and doing little or no international banking, and sending out perhaps the greatest number of wealthy travellers to places abroad, has a considerable excess of exports of goods. Germany has a large and increasing excess of imports of goods, because she also has a great mercantile marine. Australia, having had much British money invested in her undertakings, and having to pay out much interest every year, has an excess of exports of goods. Russia, also, is a debtor country, paying out much for interest and freights.

As we have briefly indicated in the preceding chapter, the payments between nations are usually effected by means of bills of exchange. Only in comparatively rare cases is it found necessary actually to remit gold in settlement of international debts. Let us take a very simple case.

France	£	Britain	£
Schaunard imports steel from Britain	1,000	Smith imports wine from France	1,000
Bonhomme exports wine to Britain	1,000	Brown exports steel to France	1,000

Let us suppose that Monsieur Schaunard in France imports £1000 worth of steel from Mr. Brown of the United Kingdom, and that Mr. Smith of the United Kingdom imports £1000 worth of wine from Monsieur Bonhomme of France. The transaction stands as shown in the table above.

It will be seen that these transactions could be settled by the shipping of gold. M. Schaunard could send £1000 worth of gold to Mr. Brown in payment for the steel, and Mr. Smith could send £1000 worth of gold to France in payment for the wine. In that case the two parcels of gold would cross each other in the English Channel, and a quite unnecessary trouble,

expense, and risk would be taken. In each country the gold would have to be bought, and packed, and insured, and freighted to the other country, and for no useful end. What takes place in practice is that when M. Bonhomme exports £1000 worth of wine to England, he draws upon Mr. Smith. He writes out a bill of exchange in the form shown in the last chapter—a demand upon Mr. Smith to pay to him (M. Bonhomme) £1000 at a certain time and place. He takes this to his banker, together with the bill of lading for the wine, and his banker puts to his credit the £1000. The banker remits this bit of paper, being the demand to pay £1000, to his agent in London.

Now let us go to England and see what happens there. The London banker to whom the Paris banker has remitted the bill of exchange obtains Smith's acceptance of the document, which means that Mr. Smith pays to the London banker the £1000 which he owes to M. Bonhomme in France. But, it will be seen, M. Schaunard of France desires to pay Mr. Brown in England for the £1000 worth of steel which he has had from him. He goes to his banker to see if he can buy a "bill on London." Such a bill is forthcoming in that which is drawn by M. Bonhomme on Mr. Smith. These bills are drawn in duplicate. The first part has been remitted by M. Bonhomme's banker to London; the second part is bought by M. Schaunard for a consideration, which is the banker's profit. M. Schaunard, having bought his bill of exchange on London, remits it to Mr. Brown in England. Mr. Brown pays it into his bank, and his banker credits him with his £1000. The reader will see that what has happened in England is that Smith's £1000 has been transferred to Brown, and that what has happened in France is that M. Schaunard's £1,000 has been transferred to M. Bonhomme. The debts have, in fact, been set off against each other, and the four parties concerned have been able to make their remittances by means of a paper demand to pay gold, drawn originally by Mr. Brown upon M. Schaunard, and accepted payable by the latter.

In practice, of course, there are a number of transactions between any two great countries at any given moment; and a citizen of France desirous to remit to England, or a citizen of England desirous of remitting to France, may or may not at any given moment find it easy to buy a bill to remit. This causes fluctuations in the exchanges, as explained in the last chapter; and, as was then explained, if bills are so scarce that it becomes cheaper to buy and remit gold than to buy and remit a bill, gold is actually sent. In practice, the system of remitting by bills of exchange has been developed into a machinery of remarkable effectiveness, and the position occupied by London as an international monetary centre is a wonderful one. A "bill on London" is the chief international form of currency, and bills on London are not only used for remittances as between Britain and other countries, but even as between two other foreign countries, in settlement of transactions which do not concern Britain. Thus, a Frenchman remitting an account to a German will send him a bill on London, so that we get the remarkable position of London acting as a financial Clearing House for foreign commercial transactions unconnected with England.

COMMERCE OF SOME GREAT COUNTRIES IN 1910.

SHOWING HOW IMPORTS MAY EXCEED EXPORTS, OR EXPORTS EXCEED IMPORTS.

	Total Imports of Goods	Exports of Goods	Excess of Imports	Excess of Exports
	£	£	£	£
United Kingdom	678,257,000	534,146,000	144,111,000	—
United States	324,364,000	363,539,000	—	39,175,000
Germany	468,809,000	397,252,000	71,557,000	—
France	364,104,000	324,196,000	39,908,000	—
Italy	137,866,000	87,553,000	50,313,000	—
Belgium	262,066,000	227,786,000	34,280,000	—
Austria-Hungary	118,869,000	100,775,000	18,094,000	—
Russia	114,572,000	152,936,000	—	38,364,000
Japan	49,417,000	47,941,000	1,476,000	—
Canada	94,728,000	59,612,000	35,116,000	—
Australia	58,698,000	69,010,000	—	10,312,000
Argentina	70,354,000	74,525,000		4,171,000

"RIDER AND HORSE, FRIEND, FOE, IN ONE RED BURIAL BLENT."

THE WORLD-FAMOUS PICTURE BY SIR EDWIN LANDSEER, R.A., ENTITLED "WAR," WHICH HANGS IN THE TATE GALLERY, MILLBANK

THE TRAGEDY OF WAR

An Amazing Survival in Times of Comparative Civilisation of the Brute Habits of Man's Earliest Progenitors

DECLINING CAUSES OF NATIONAL STRIFE

That society should have reached its present state of organisation in morals, industry, education, and art, and yet should be suffering everywhere from the nightmare of war, is the strangest phenomenon of life. Yet we are so accustomed to it that we do not see its strangeness, except in moments of deliberate reflection. If a visitor from another planet could see human life in its higher developments—its sentiments, aims, ideals—the last thing he would predicate of a race that claims to be rational would be war. Such a state of things as war would appear to him to exceed the utmost bounds of possibility. He would see men of all the white nations that control the world promoting organisations for securing the rule of Christianity in human hearts, the rule whose primal promise is "peace on earth and goodwill to men." He would see outside of the elaborate organisations of Christianity, but co-operating with it, vast reserves of humanitarian feeling, human tenderness, love of what is kind and gentle. He would see men united everywhere in acknowledging, conserving, extending the sense of life's sacredness. He would see that the preservation of the race from pain, distress, and death is occupying the thoughts of myriads of the best minds, and that the mass of men are filled with sympathy for these efforts. He would see that the revulsion from taking life is so strong that even the men who themselves have taken the life of others, by foul murder, in defiance of the general sentiment and of most carefully devised human ordinances, are often protected from the death they have incurred. He would find that a number of States, in revolt against taking life, have, by legislation, abolished capital punishment, deliberately and formally.

And then, on the other hand, he would see that each of these States, and all the rest, make arrangements, at vast expense, for the wholesale massacre of the men of other States in tens of thousands. He would see that human ingenuity, so marvellously developed throughout the ages, with constantly accelerated speed, and ever-broadening range, is tolled first of all in the interests of death. Each fresh invention is used to perfect the means of destruction. More could not be done if man's first and foremost object was to kill his fellow-man. Enormous numbers of mankind live and think for this awful purpose. If the time comes for them to use their dreadful art, and they succeed with a terrible completeness, they are honoured and rewarded by their fellow-men belonging to the same State as themselves.

And, strangest of all, the victims of these war crises, in three cases out of four, have no idea what cause the war represents; nay, usually it represents no imperative cause whatsoever, but is proved by later history to be the result of a mistake on the part of the promoters and managers of war. The scene has been pictured once for all by Thomas Carlyle, in "Sartor Resartus."

"What, speaking in quite unofficial language, is the net purpose and upshot of war? In the village of Dumdrudge dwell and toil usually some five hundred souls. From these there are selected, say, thirty able-bodied men. Dumdrudge, at her own expense, has suckled and nursed them; she has, not without difficulty and sorrow, fed them to manhood, and even trained them to crafts, so that one can weave, another build, another hammer, and the weakest can stand under thirty stone avoirdupois. Nevertheless, amid much weeping and swearing, they are selected, shipped away, and fed till wanted. And now to the same spot thirty similar artisans

from the Dumdrudge of another country are in like manner wending; till at length, after infinite effort, the two parties come into actual juxtaposition; and thirty stands confronting thirty, each with a gun in his hand. Straightway the word 'Fire!' is given; and they blow the souls out of one another; and in place of sixty brisk, useful craftsmen, the world has sixty dead carcasses, which it must bury, and anew shed tears for. Had these men any quarrel? Busy as the Devil is, not the smallest! They lived far enough apart; were the entirest strangers; nay, in so wide a Universe, there was even, by Commerce, some mutual helpfulness between them. How then? Simpleton! Their governors had fallen out; and, instead of shooting one another, had the cunning to make these poor blockheads shoot."

The Supreme Folly Men are too Blind to See

Furthermore, war, as reasoning men are now beginning to see, cannot by any conceivable process bring final profit to either party, but must leave the victors, as well as the vanquished, economically worse off than before, with new hatreds, and therefore a new legacy of war, as the most tangible result. Could unreason and negation of manhood go further? Could anything more irrational and contradictory be conceived than this contrast between the advance of man in civilisation and moral elevation and mastery over the beneficent powers of Nature on the one hand, and reversion to the gusty passions of primeval savagery on the other hand? What could the visitor from the neighbouring planet think of man's achievements judged by his obsession under the influence of the nightmare of war? This is the broad contrast that is war's salient feature, though custom may blind us to its appalling folly.

The Last Cherished Relic of Man's Savage Beginning

How comes it, then, that civilised man, with his regimented Christianity, his worldwide organisation of interdependent trade, his increasing appreciation of neighbourly intercourse between nations, is still a slave in thrall to the primitive instinct of war? The explanation, of course, is that war-making is a practice so interwoven with man's whole evolutionary history that he has not yet been able to get rid of it as outdated. In the earlier ages of the world he had to fight with rough violence for his place on the planet, against other powerful creatures, and rival men. Failure meant extermination or slavery. There was no room for the non-fighter. So fighting became not only the criterion of the early man's success but his sport and joy.

If any comfortable person, sleek and timid, doubts the reality of this impulse he may correct his impression by noticing how the same instinct has sprung up, for the same reasons, in the dog. It, too, fought for its living and its life, till modern days gave it domestic ease; and even now the dog of spirit loves a lively battle for the sake of the excitement and adventure. A healthy boy who lives with other boys, in the manner natural to boys, retains the primitive tendency to fight spontaneously; and all the savage races that have any grit in them make fighting the readiest test of manhood. Sheer animal pugnacity is thus bred in man—a dangerous inheritance; but that is no reason why it should not be conquered, or turned into useful channels as the characteristics of savagery are discarded under the influence of knowledge and a higher morality. Mankind has been weaned, on the whole, from other original vices, such as theft—weaned by a variety of processes of which the "taboo" is perhaps the most prominent; and there is no reason why the weaning from war should not proceed rapidly, and so give civilisation a sense of reality which, because of war, it does not yet possess.

The Proximity of Savagery and Civilisation as a Cause of War

If a larger portion of the earth were civilised the task of excluding war from man's communal enterprises would be much easier, for now nearly every stage of evolutionary progress is represented contemporaneously in the world with some of the greatest contrasts side by side. The man who is in the Stone or Bronze Age is in contact with the exponent of the latest phases of civilisation. To the first, fighting is almost as natural as breathing, and that must be known and be prepared for by men in the latest stage of evolution. The Zulus and Soudanese had to be "sloshed with Martinis," or they would have swept civilisation from South Africa and Egypt; and no Power can reason the rifle out of the hands of the Afghan or the Albanian. While the boundaries of savagery and pacific law are co-terminous, it is useless to preach entire disarming. So war is kept permanently among the things that are deemed inevitable; and the human conscience, so readily dulled by custom, is not allowed to escape tradition and do its perfect work.

Unresisting Christians — extraordinarily few in numbers—will say that everywhere, whether with civilised peoples or with savages, entirely peaceful methods would succeed better than the use of force; and that the soft answer would quench frenzied wrath more effectually than the quick-firing rifle. It may be so, but men in the bulk have never been able to believe it. True, some wonderful records are extant of the positions gained among fierce races by fearless disciples of the Prince of Peace, but these stories of the power of the gospel of gentleness come chiefly from the periods when pioneer missionaries, such as the earlier Jesuits, were not hampered, beyond the bounds of civilisation, by the habits of other adventurous white men, who knew little of peace. Christianity, as a whole, has never discarded war. It has been content to regard its own tenets as offered for individual use, and war as embraced in the things that can be properly rendered to Cæsar; while Governments have rarely reached a high ideality. Indeed, we may be thankful when they practise ordinary honesty and morality, and do not trickily shift the grounds of their national business, or tear up the most solemnly made treaties to suit their temporary circumstances. The stoppage of war can neither be expected from organised Christianity nor from Governments moved by splendid moral motives.

Industrial Expansion by Emigration no Excuse for Aggression

And yet it is coming nearer, thanks chiefly to the common sense, prudence, and growing humanity of the mass of intelligent men. The tendencies towards peace, with their methods of hope, shall be discussed in our next chapter—here we confine ourselves to a preliminary examination of some of the influences which retain war in our midst, and others that modify its effects.

Perhaps the most insidious idea that is afloat, with a general acceptance, is the claim of a growing nation to indefinite expansion—as a nation. It is never distinctly formulated, but often is tacitly admitted. If it were acted on there would be a danger of wars recalling the disturbed state of the Middle Ages. Germany has a surplus population; why should she not absorb whatever lands she can lay her hands on? And so with Austria and Russia and Japan, and any other nation. Of course, the world must be open for the expansion of a growing and confined people, but it *is* open, except in the cases of the Chinese and Japanese; and experience throughout the British Empire, the United States, and the South American continent shows that outlets can be found for population and national energy without any need for the home country to follow up its emigrants with a national organisation. The German in the United States or Canada or the Argentine Republic is at least as free to work out his destiny as he would be if he were a citizen of a German State. If Brazil is waiting for conquest by industry, that conquest can come readily enough from any part of the world, without conquest by arms. The world has reached a stage in commerce when expansion is admissible without aggrandisement, and racial development need not endanger peace. Freedom in trade is the one great condition, but that would be fatally affected by European expansion in the form of a series of closely preserved national conclaves.

The Danger of the Theory of Irresistible Racial Waves of Population

Whether the supposed interests of great racial combinations will lead to future wars is a question that only rashness would answer. In Europe the Slavs are the one people of common origin who might raise the problem, but they are now divided by many local associations, and each section has felt the disadvantage of exhausting wars. There is no doubt that the most vital division in Europe is that between the Slavonic and Germanic peoples. Other oppositions are secondary to this great rivalry. The stupendous magnitude of the issues that would be involved if such vague racial jealousies took more definite shapes is the best guarantee of peace.

Artificial Political Combinations the Most Fruitful Cause of War

But, unfortunately, the existence of these jealousies gives rise to a complication more dangerous than the chief latent antagonism. The arming of Russia against Germany and Austria, and Germany and Austria against Russia brings all the rest of the principal Powers into more or less definite combinations, and with each growth of alliances and understandings the area of possible friction is extended. Artificial political arrangements have always been the most fruitful cause of war. If each country fought its own battles, and was never drawn into conflicts that did not directly concern it, there would be very few wars. The reason why Carlyle's slain soldiers of Dumdrudge did not understand why they were fighting was because, in all probability, they were enabling their

THE RUTHLESS ENMITY SOWN IN MEN'S HEARTS BY WAR, IN THE DARK NIGHT OF TIME

IN GUSTAVE DORÉ'S PICTURE "IRRECONCILABLE" WE SEE AN ENSIGN OF HUSSARS, WITH BLOOD NOT YET COOLED, SHOOTING DOWN AN OFFICER OF THE ENEMY AFTER THE BATTLE

THE TENDERNESS THAT SUCCEEDS WAR'S FURY AS THE LIGHT OF CHRISTIANITY SPREADS

IN "RECONCILED," BY GUSTAVE DORÉ, THE REPENTANT ENSIGN, THE COLOURS TIED ROUND HIS BODY, IS HELPING HIS WOUNDED ENEMY IN THE DAWN OF A NEW DAY

country to keep honourably some unnecessary, and therefore unwise, diplomatic promise of help to another country in difficulties. The least hopeful sign of lasting European peace is the tangled skein of diplomatic commitments. No one knows what pledges may plunge any particular nation into war. The most fateful of national decisions are still made, as they always have been, in secret, by a few persons; and the action of these few may depend upon the action of a few others. These official persons, too, live in an atmosphere which is often more or less charged with the threat of war. War is their familiar in thought, and so they are the least likely to see its heinousness from a detached and humanitarian standpoint.

The Influence of the Professional Fighting Man in Causing War

This brings us to another permanent danger—the influence of a large, omnipresent, active class, with considerable social and historical prestige, whose business it is to conduct war. The fighting-man is honoured by the average person for two chief reasons. History, as it is popularly known, is full of the exploits of such as he, and so he is surrounded by a traditional glory; then, too, he stakes his life for his country, suddenly, dramatically,

> What time the foeman's line is broke,
> And all the war is rolled in smoke,

and everyone can understand the heroism of a life so offered better than a life given in long and patient civil or industrial endeavour. Let no one grudge the recognition given to the honest soldier who is the first to volunteer for a danger which is every man's duty. But, undoubtedly, the general effect of the soldier's calling is to bring war about, by living with the thought of it till it takes a false glamour, by expecting it, assuming its coming, and, in obedience to professional impulse, stimulating the feelings that tolerate it.

The Danger of Playing on the Passions of the Populace

In many cases the action of the military authorities has precipitated war. So familiar is the idea of warlike action by land and sea that all the world will discuss, from time to time, the possibilities of a great military or, preferably, naval *coup*. The thinking of a fighting-man must necessarily tend to run in a groove; fighting becomes to him inevitable, and, as one who is supposed to know, he impresses others. There would soon be no war between civilised nations if there was no military caste. The revulsion from war is only a late product in human evolution—a result of reflection, of economic considerations, and the growth of finer human susceptibilities; but, if once the primal passion for fighting is rekindled, the results are incalculable. That tendency to obey waves of feeling is, at a certain stage, the greatest danger to nations. The scheming of diplomatists, the professional pride and importance of trained militarists, the dictates of prudence, may all be swept away in a rush of popular fury, when men, *en masse*, return to the instincts of their far-off ancestors. The military extremists, the party wirepullers, the sensational Press are playing in the close neighbourhood of uncontrollable fire when they dally with war as an imminent possibility. Who can tell when passion will burst out and pandemonium will begin? The fiend is but shallowly buried in millions of seemingly quiescent natures. None of us can afford to forget that civilisation balances on a very narrow edge.

Great but Quiet Influences that Work Constantly for Peace

And yet the dawning of a day of peace when the madness of war will be known as in truth a madness, cannot be far away. A whole set of ideas that are comparatively new to the world is influencing thoughtful men, and must have a deep effect. National rivalries are seen to be quite flimsy in comparison with the constant opportunities for international helpfulness. Trade interweaves the interests of nations in many vital ways. More and more capital is cosmopolitan in its operations. More and more the workers in the Dumdrudges of every country are asking why they should be asked to slay each other, and no one can give them a satisfying answer in the name of war. More and more the burdens of war, hampering the progress and happiness of the masses of mankind, are felt to be the remnants of an outworn system, relics of a low or superseded stage in civilisation.

And when war does come, the pity of it is felt infinitely more, and the "glory" infinitely less, than ever before. All the nations rush forward to help to heal, in some degree, the wounds the war has made. The hearts that bleed are not found alone in the nations that are grappling with each other to the death. The stupendous folly and wrong of it all sink into a myriad minds, and convince them that there must be a better way. Towards that better way we will next direct our thoughts.

NATIONAL EUGENICS

The Legislative Outlook for the Great Cause of Human Welfare at the Dawn of 1913

THE TERRIBLE PROBLEM FOR FRANCE

It has never been argued in this section that legislation is omnipotent, or that substantial good can flow from any cause other than the increase and dissemination of knowledge—which the Romans called science. Yet the time must come when the advance of scientific knowledge and the instruction of public opinion have their normal issue in official and legislative action. Thus, before we bring to a close the statement of eugenics which this section comprises, it is necessary, in the interests of progress, and for the purposes of the future student of eugenic history, to state the prospects and conditions of National Eugenics, to use Sir Francis Galton's favourite phrase, as they present themselves at the dawn of the year 1913.

For convenience, we may begin with our national ally, the great French nation, in which the problems of the birth-rate have long been urgent and of increasing urgency. The facts of the French population are now just what students have long asserted. Their statements and their prophecies have been justified. The fall in the birth-rate, which began so early in France, and has proceeded so far, is still maintained. In the year 1911, the last of which we have a complete record, the number of deaths in France, though gradually diminishing, exceeded the number of births. The indigenous French race is disappearing—at any rate, in France. Population has become practically stationary, and is apparently maintained, in so far as it is maintained, by immigration into France from Germany, Switzerland, and Italy especially. But in Germany, notwithstanding such emigration, the population continues to increase—though the birth-rate falls—to the extent of nearly 900,000 per annum, which is more than twice the annual increase in Great Britain, and is, of course, a most ominous contrast to the case of France.

In these circumstances babies become precious, being so scarce. Yet though that is evidently true from the standpoint of national eugenics in France, the loss of life is very large, even while the amount of life to lose steadily diminishes. A falling death-rate and a falling birth-rate usually accompany one another, as in this country, but the death-rate in France is very far from falling as it should. Even though France is the undoubted pioneer of the modern campaign against infant mortality, the conditions of infancy and child life are such as to cause an enormous wastage. It is also noteworthy that, for some years past, the amount of alcohol consumed in France has been rising (doubtless in association with urban aggregation and the great power of the liquor trade over the State) and the evidence of pulmonary tuberculosis, as might be expected, has risen concurrently.

Yet historically, and at the present day, France was, and is, one of the very greatest countries in the world. Our debt to the French race, in terms of scientific achievement alone, is immense. Chemistry has been said to be a French science, and such names as Lavoisier, Berthelot, and Becquerel go far to justify the boast. In the realms of biology and medicine, France can boast many names among the greatest, and hers is the greatest name of all—that of Louis Pasteur.

The famous Institute which bears his name now makes Paris, under the guidance of such men as Roux and Metchnikoff, the leader of the world in the study of the laws of life and health. No lover of mankind, no believer in the human destiny, is worthy of the name who would not deplore the decadence of the race which has such achievements to its credit. Yet the present facts of the French people are as we have just stated. It has been said that one omen of good

import is available to contrast the prospects of modern nations with those of their predecessors. It is that we are aware of our danger, as apparently the great nations of antiquity were not. There can be no question that France is aware of her danger, and proposes to study and meet it manfully. In so doing, France is only playing the pioneer once again. The conditions which she is about to study are those of her own people, her own habits, her own cities; but every student knows that what will be found for France will be substantially true of civilisation at large. The laws of life are uniform enough for that.

The Vital Importance to France of the Eugenics Commission now Appointed

The very highest importance, therefore, attaches to the great Commission which the French nation has just appointed, to study what we may call, in brief, the National Eugenics of France, and to which very brief reference has already been made here. That Commission will deal with the whole question on a scale hitherto unprecedented, and no one who knows the quality of French thinking, or the vital seriousness of this question for France, can doubt that the conclusions which this Commission reaches will form a starting point for national eugenics in every civilised country in the world.

A former Commission, which reported in 1902, a decade and more ago, was fruitless. Some years must pass before the new Commission is in a position to report, and meanwhile every Eugenist should be acquainted with the conditions and scope of the inquiry, and should endeavour to follow it as far as possible. The decree appointing this great Eugenics Commission, as it really is, was signed in November, 1912, by President Fallières, having been presented by M. Klotz, the Minister of Finance.

The Search for a Solution of the Terrible Problem of France

The Commission is to study "all the national questions, social as well as fiscal, which bear upon the depopulation of France, and to seek to discover a remedy." The fact that the Minister of Finance presented the decree is significant. Everyone knows that the fall in the birth-rate has economic connections, and that the sacrifice of infant and child life is largely dependent upon economic conditions.

M. Klotz observes that in his opinion all the attempts hitherto made in France by successive Governments to combat the depopulation of the country have been half-hearted, and have only resulted in partial and ineffective measures. The question, says this Minister of Finance, is one of *national defence*, and must, as such, be expected to entail heavy expenditure. The failure of the Commission of a decade ago is stated by M. Klotz to have been due chiefly to the fact that the financial aspects of the question were ignored.

The Commission now set up, under the presidency of M. Klotz, consists of more than a hundred members, including several ex-Prime Ministers of the French Republic. It is a genuinely expert body, and is to be divided into five sub-commissions, as follow: "(1) Administrative and legal, to inquire into naturalisation and marriage laws, the question of infanticide and kindred evils; (2) military, which will examine the effect of the birth-rate on recruiting and army organisation; (3) social, to study infant mortality, hygiene, intemperance and tuberculosis, together with questions of assistance to mothers, and of the proper education of the sexes; (4) financial, to decide how best to encourage larger families, and how to help those which have become too large for their parents' financial means; (5) a central sub-commission to collate and examine the reports of the other four sub-commissions, and to draw up the final report." M. Caillaux, a former Prime Minister, will preside over one section; and M. Ribot, another ex-Prime Minister, will preside over the central section.

An Official Admission that the Expansive Power of France is Being Weakened

The proceedings of this National Commission were opened with a speech by M. Klotz, and, having noted what he said, we may conclude our reference to a piece of work which will doubtless establish an epoch in the history of National Eugenics. M. Klotz began by calling attention to the gravity of the facts. After quoting certain figures from the great European nations, to which we have already referred, he observed that, though a diminution in the birth-rate is very general, nowhere does it bear comparison with the diminution in France, which, if unchecked, would lead to "military and economic inferiority, and a weakening of the expansive power of France in the world." He quoted remarkable figures of the French people in 1908—figures almost incredible, and well worthy of record. In 1908 there were in France 1,350,000 unmarried men over thirty years of age, and a somewhat larger number of unmarried women. There were 1,804,710 families without children, 2,661,978 families

with only one child, 2,966,171 families with two children, 1,643,415 families with three children, and only 967,392 families with four. The total number of families with four children and more was only 2,328,780.

M. Klotz notably referred to measures of hygiene and factory legislation, as well as the question of the housing of large working-class families. He said that the Commission would examine the possibility of ameliorating the financial position of the parents of large families. There were difficulties in the way of a reduction of taxation in the case of such parents, as that course would entail the imposition of heavier burdens on the rest of the community; but he thought that the Government, without the intervention of Parliament, could favour the parents of large families in appointment to petty public offices, and could help the children by giving bursaries at school.

The time will most certainly arrive when we find ourselves compelled to appoint a Royal Commission on Eugenics in this country; and to agitate for such a Commission has undoubtedly become a duty laid upon Eugenists. Meanwhile, a semi-official step has been taken here, which will have notable consequences, and which closely corresponds in spirit to the French Commission.

A British Association for Promoting the Welfare of Infancy

Just when that Commission was being appointed on the other side of the Channel, we here formed a body called the "National Association for the Prevention of Infant Mortality and for the Welfare of Infancy." Two national conferences on infant mortality have been held in this country, and the executive committee of those conferences decided that, not least with a view to the developments of "maternity benefit" under the Insurance Act, it was desirable greatly to extend the work for the care of the nation's infancy. Various other bodies were approached, and the new association just named is the consequence. Sir Thomas Barlow, the President of the Royal College of Physicians, the first living authority on diseases of young children, is chairman of the Executive Committee.

The first act of the new body has been to arrange for a course of lectures on the care of infancy, meant for the education in this subject of the medical profession, for it is the notorious fact that medical students are not instructed in this subject, and that the University of Belfast is the only body granting medical qualifications in these islands which requires that its students shall have studied the care of infancy. The statement will be incredible to most readers, but it is true.

It is well known to students of the public health that we neglect our children between infancy and the school age. The "home child" is forgotten. A movement has now been started for the medical inspection of such children, and those who know anything of the condition of school-children on entering school will be well aware how necessary such a movement is. The National Association is specially intended to deal with this problem, and to seek the welfare not only of infancy but also of young childhood, until it reaches the school age and comes under the care of the education authority.

The White Slave Bill a Small Instalment of Eugenic Legislation

The battle of eugenics is fought on many fields. Not least important is the Parliamentary arena, at which, after long delay, certain eugenic questions have lately arrived. A small but definite step is to be recorded, thanks to public opinion, to the feeling aroused by the death of Mr. W. T. Stead on board the "Titanic," and to the activity of the National Council of Public Morals, which has for some time devoted almost all its efforts to the campaign for race-regeneration, under its admirable Director, the Rev. James Marchant. The step in question is the passage of the Criminal Law Amendment Act, now generally known by the appellation of "White Slave Traffic." This cannot possibly be regarded as a very large or as in any sense a fundamental measure, but it does deal, in some small but definite degree, with the protection of young womanhood and of the future—above all, from the racial poisons of disease. Let it here be declared to be our National Monument to Mr. Stead.

The Bill Only a Deterrent that Avoids Dealing with the Causes of Evil

Though most of us worked for the passage of this Act, we are bound to observe that Eugenists to come will not look upon it very highly. None of the underlying causes which make the "White Slave Traffic" possible are dealt with in this Act. It seeks to make the law a terror to the evil-doer; it will consequently deter nearly all but the most callous and daring villains from participation in the traffic in this country, and it will enable us to interfere more effectively with the foul doings of those who are not deterred. But the Act does nothing whatever against the ignorance which permits the trapping

of so many girls; it does nothing to remedy our present neglect of adolescence, and it does nothing against the alcoholism which is the ally of the white slave trader at every turn, and without which the traffic could not be continued at all.

Most notably, the Act does nothing to raise what is technically called the "age of consent"—the age at which a child may consent to her own ruin, and so secure immunity for the blackguard who achieves it. Until 1885 this age was thirteen; and if we marvel at the law which regarded a child of that age as competent to care for her life and her body and her honour, we must remember that the legal age of marriage in this country is still *twelve years.*

John Ruskin's View of the Crowning Sins of Society

In 1867 John Ruskin had written these words: "The two crowning and most accursed sins of the society of this present day are the carelessness with which it regards the betrayal of women and the brutality with which it suffers the neglect of children." In practice, the nominal sixteen becomes a practical fourteen years of age, according to judicial practice; and no decent person can pretend that, at either age, a child is fit to decide whether or not she shall, in her ignorance, "consent" to her own ruin. It is deeply to be regretted that the opportunity was not taken, in the Criminal Law Amendment Act, to raise the age of consent to eighteen or twenty-one, and so bring our standard up to that which can be seen in, for instance, some of our own Colonies.

The Palpable Failures of the Criminal Law Amendment Act

What is the moral or psychological value of "consent" at such ages, and under the necessary ignorance of the inexperienced, is a question which we need not here discuss, though it may evidently be asked, regarding the normal-minded victims of white slavery and of prostitution. But the question answers itself when it has reference to the half-witted girl, the "mental defective" who is so apt to fall into the traps laid for her. And unfortunately the Criminal Law Amendment Act does nothing to deal with the causative feeble-mindedness which underlies a part of this problem. In the circumstances we can only marvel at the "sancta simplicitas" of the illustrious prelate who, in advocating the claims of this Act, declared that its passage would solve the problem. The successful passage of this Act, against the apathy and hostility of many members of Parliament, is a striking testimony to the force of public sentiment; but it enforces, only too completely, the truth that public sentiment is more easily aroused than the public mind is enlightened. It will be when we get the union of heart and head in such questions that they will be solved, and it will be then alone. Yet the few who know what, for instance, is the fate of the feeble-minded under our present conditions are well aware that it would nowhere be possible, neither in the Congo nor in Putumayo, nor anywhere else, to find miseries more cogently appealing to humane sentiment, if only the public ear were not so deaf and the public imagination so dull.

Chronic inebriety is one of the conditions which urgently demand legislative attention at the present time. We have already discussed the scientific aspects of this subject, and have seen that it concerns the Eugenist in several ways—the inebriate as a parent may really be a feeble-minded parent whose condition has not been recognised, and we know that characteristic to be transmissible; the inebriate as parent may suffer from alcoholism affecting the germ-plasm, and so giving rise to racial poisoning; and the inebriate is not fit for the nurture of children, quite apart from any questions of heredity or racial poisoning.

The Notorious Inadequacy of the Law for Dealing with Chronic Inebriates

Here, therefore, are three distinct and cogent grounds on which we are bound to demand powers for dealing effectively with chronic inebriates; and these grounds supplement others more obvious and no less cogent—namely, the fact that, very frequently, the only hope for the inebriate is that he or she may be treated and protected willy-nilly, and the further very evident fact that the chronic inebriate is apt to be a source of danger and injury to the presently existing community. So notoriously inadequate is the law for dealing with inebriates that a Departmental Committee was appointed, and reported early in 1909, since which date the subject has appeared in a King's Speech as one for early legislative attention, but nothing, after four years, has yet been done. The eugenic attitude in regard to this question is stated, not completely, but sufficiently for the purpose, in the following memorandum submitted by the writer to the Committee on behalf of the Eugenics Education Society.

"It may be pointed out that the children of the drunkard are on the average less capable of citizenship, on account of—

"(*a*) The inheritance of nervous defect inherent in the parent.

"(*b*) Sutra-uterine alcoholic poisoning in cases where the mother is an inebriate.

"(*c*) Neglect, ill-feeding, accidents, blows, etc., which are responsible on the one hand for much infant mortality, and combine, with the possible causes before mentioned, for the ultimate production of adults defective both in body and mind.

"It would appear, then, that the drunkard, if not effectively restrained, conduces to the production of a defective race, involving a grave financial burden upon the sober portion of the community, to say nothing of higher considerations. . . . Some substantial effort should be made for the reform of existing drunkards, or for the permanent control of the irreformable.

The Abundant Scientific Warrant for Grappling with Drunken Parenthood

"Scientific warrant for the foregoing propositions is now to be found in no small abundance. Reference may be made, for instance, to the chapter on 'Alcoholism and Human Degeneration' in Dr. W. C. Sullivan's recent work 'Alcoholism' (Nisbet, 1906). Dr. Sullivan quotes the results of more than a dozen observers in this and other countries, and special attention may be drawn to his well-known study of the history of 600 children born to 120 drunken mothers. The works of Professor Forel, of Zurich, are widely known in this connection, notably 'The Sexual Question' and 'The Hygiene of Nerves and Mind.' Parental alcoholism as a true cause of epilepsy in the offspring is now generally recognised. For numerous and detailed proofs from many sources reference may be made to page 210 of the last work named.

The Precedents for Legislation Afforded by other Countries

"It is not necessary, however, to go over the ground which has doubtless been covered by the Royal Commission on the Care and Control of the Feeble-Minded.

"The existing laws comply to only a very small and negligible extent with the eugenic requirement. They only deal with (*a*) the very minute proportion of inebriates who can be induced to voluntarily sign away their liberty, and (*b*) those who are also criminal or all but hopeless, and who have done harm already, either as individuals or in becoming parents. The third group of inebriates (*c*), not included in (*a*) or (*b*), constitutes the overwhelming majority of the whole. They are absolutely untouched by the present law, and further powers are urgently required to deal with them.

"Such legislation would be by no means without precedent, and may avail itself of the experience of several of our own colonies and various foreign countries. Such methods as compulsory control on petition, guardianship, and so forth are in employment, for instance, in the Australian Commonwealth and New Zealand, California, Connecticut, Massachusetts, various cantons in Switzerland, Nova Scotia, etc.

"To sum up, the Society advocates the retention of the present law so far as (*a*) and (*b*) are concerned, but would most strongly urge the addition of powers to deal with that great majority of inebriates whom the present law does not touch."

The report of the Departmental Committee, now four years old, is in conformity with the arguments above presented to it. At last a Bill has been prepared by the Home Office, and this Bill actually passed its second reading in the House of Commons in the summer of 1912. Nothing more has since been heard of it, and the Bill must doubtless be reckoned as lost.

The Scandalous Neglect of Protection for the Innocent and Helpless

The measure was reasonable, moderate, non-partisan; it introduced no new principle into legislation, and would still have left this country behind some of its own colonies in dealing with the inebriate. It should have been actively supported by the temperance party everywhere, for it would have served to reform some drunkards, and would have protected the young, innocent, and helpless from the drunkenness of far more; but it has regretfully to be acknowledged that the temperance party, as a whole, has appeared to be unaware of the existence even of this measure, and has shown little alacrity in any direction which does not promise a direct attack upon the licensed trade. Yet further, the licensed trade itself should have supported this Bill, which would have served to deal with the hopeless and scandalous drunkard, and thus to remove one of the chief causes of scandal against the trade. It is to be regretted, also, that the various eugenic societies, though one of them had actively worked for the drafting of such a Bill, did nothing to support the measure when it had actually got as far as its second reading in the House of Commons. Thus, from lack of any efficient support from any

section of the community, the Bill has been dropped. But the problem remains, and must be solved, for it is one of those problems that have the power of self-perpetuation. Meanwhile, no one can do more than persistently and hopefully to advance the education of public opinion until this scandal of the neglect of the inebriate, with its injury to him or her, to the community and to the future, is removed.

The legislative treatment of the problem of mental deficiency remains. The Report of the Royal Commission referred to in the above memorandum will soon be five years old, yet nothing whatever has been done. The record of attempts in the right direction is little creditable to politicians. As nothing could be obtained from the Home Office, notwithstanding the ever-swelling volume of voices of protest—including *all* parties, as the First National Conference on the Prevention of Destitution showed—the National Association for the Feeble-Minded prepared a short and simple Bill, without any financial provisions, and had it promoted by a private member, in order to rouse the Home Office to competition.

The Strange Omission of Legislators in not Consulting Practical Experience

The device was successful, and the Home Office obtained the shelving of the small measure, by undertaking to promote a much larger one, which it prepared itself. This was the Mental Deficiency Bill, the abandonment of which caused a great quickening of public opinion in this country in the autumn of 1912.

That Bill is now a matter of mere historical interest, and need not delay us long here. It was well meaning, and would have been very useful, but it had serious defects, as might be expected, since it was drafted without any attempt to consult those who knew most of the task which the Bill proposed to accomplish. Of all the inhabitants of this country, one stands in a unique position in regard to this question. That one person is Miss Mary Dendy, who has given her life to the permanent care of the feeble-minded, and whose Home—or, rather, the Home of the Lancashire and Cheshire Incorporated Society for the Permanent Care of the Feeble-Minded—at Stalybridge, near Manchester, is the very model of what all such places should be. There for many years past this Society and Miss Dendy have solved the problem of the feeble-minded, so far as the law and their financial resources would allow them, and have done so in the ideal way, providing for these unfortunate people every kindness, care, sympathy, and protection, while completely protecting the future from what would be the certain consequences of parenthood on their part. But Miss Dendy and her Society were never approached or in any way consulted by the Home Office when it was drafting the Mental Deficiency Bill. The fact is worthy of record as a recent and flagrant illustration of the truth of Oxenstiern's remark "with how little wisdom the world is governed!"

The Hope of New Laws for Enforcing Wise Care for Feeble-Minded Children

As these words are written, a new Bill is being prepared, and this time the Home Office is calling experience and ripe practical judgment in aid. It is practically certain that in the first half of the year 1913 the greater part, though not the whole, of the problem of the feeble-minded in this country will be potentially solved by the placing of a suitable measure upon the statute book. That measure will enable the nation to continue, so long as they need it, the care of its feeble-minded children, whom we now "educate," at great expense, in our special schools, and abandon at the age of sixteen, when our care of both sexes should obviously be redoubled. In that measure the nation will undertake to make the necessary financial provision for dealing with the question. And, very notably, the principle will be recognised that there must be regularly repeated annual inspection of the inmates of colonies, as in the case of lunatics, so that the rare individual whose case has improved, and who therefore turns out not to have been a true case of feeble-mindedness at all, may be quickly identified and discharged.

The Limits Set by Nature to Legislative Reformation

The placing of such a measure on the statute book will mark an epoch in the history of National Eugenics. But we who have studied the recent work of the American Eugenics Record Office, and who know that true mental defect is a Mendelian recessive, are aware that the problem of the "impure dominant," the personally normal individual who yet carries mental defect in half of his or her germ-cells, remains for solution. Here, evidently, no legislative remedy is applicable. Public opinion and a high standard of knowledge and of personal responsibility in proportion to knowledge can alone avail.

SUN-CLUSTERS AND NEBULÆ

Various Aggregations of Celestial Lights, from Star-Groups to a Feebly Luminous Nebular Fog

THE GORGEOUS DIADEM OF THE PLEIADES

We have seen that double stars, or systems of two stars physically related to one another, are extremely common in the heavens; and, further, that with improved means of observation these binary systems tend to reveal a more and more complex nature. Systems of three, four, or more stars, variously related, are known to exist, and some progress has been made in discovering the nature of their relations. But these small systems hardly prepare us for the astounding phenomena of star-clusters, which appear like supreme works of celestial jewellery.

The familiar acquaintance with the night-sky, which country people have from childhood, accustoms the mind to the idea of large numbers of stars grouped together with architectural design in the constellations, and therefore physically related to one another. It is true that a very little learning is enough to show that this impression is largely erroneous, and that the grouping of the stars in constellations is principally no more than the optical effect of perspective. But the progress of astronomy is always finding actual relations between celestial bodies; and when the lay mind takes for granted that the stars of the Great Bear or of Orion are obviously related to one another, it is instinctively scientific, because it derives its sense of physical union from the evidence of formal design. The argument from formal design is, in fact, one of the chief evidences which astronomers bring forward when they assert a real physical relation between the members of a star cluster or group.

The most famous of all star-clusters has been known and honoured from the earliest days. The Pleiades are perhaps the most illustrious of all heavenly systems; many primitive peoples have felt that they had some profound concern in the affairs of human life; and the phases of their rising and setting have been accepted as a calendar by toilers of the land and of the sea. And now the members of this vast group have been proved to be related in a real systemic union, by their possession of a common proper motion. It is probably only an apparent motion, due to our own sun's journey through space, but is no less convincing on that account, since it is found to be exactly the same for all the members of the group. Their mutual positions maintain complete rigidity, showing that, as one moves, so do all the rest.

They form, indeed, a most marvellous and majestic group. Their distance from us is believed to be at least two hundred and fifty light-years; yet even at this enormous distance the chief star, Alcyone, appears of the third magnitude—a fact which proves it to be nearly two hundred times more powerful as a luminary than our sun. Sirius himself, being only sixty-three times as bright as our sun, would come but seventh in respect of brilliancy among the chief stars of the Pleiades, if he were situated among them. The principal stars of the group are six in number—viz., Alcyone, Electra, Atlas, Maia, Merope, and Taygeta, all of which are of fifth magnitude or greater. The general form of the group, as seen by unaided vision, is well known, and is due to the positions of these six stars, Alcyone occupying a central position, though probably not really exercising a dominant influence on the rest of the group.

The number of stars actually belonging to the system of the Pleiades is at present undetermined. Over two thousand three hundred, down to the sixteenth magnitude, were counted in 1887, and four thousand stars appeared on a photograph of the region taken ten years later. But it is almost certain that only the most brilliant

actually belong to the group. Most of the small stars appearing within its area are known, by the absence of proper motion, to be only visually connected with it, and to be actually at immense distances beyond it in space. Some of its brighter stars, on the other hand, have proved to be much nearer to us than the Pleiades; they display a proper motion in excess of that which is characteristic of the group, and are therefore known to be crossing the plane of vision between us and the Pleiades. But at least forty-five of the stars which have been specially studied are known to be true members of the group. These, with perhaps many smaller stars not yet determined, and having Alcyone in their centre move together through the heavens, probably pursuing at the same time many and various mutual revolutions among themselves, forming subordinate systems within this gorgeous diadem of resplendent suns.

Yet the spatial extent of the Pleiades is so vast, and their distances from one another so great, that even Alcyone, with its two-hundred-sun-power of brillancy, only reaches the nearest of its great companions as a supremely bright star, some eighty or ninety times as brilliant as Sirius appears to us, and with a power almost sixty-seven thousand times less than that with which our sun reaches the distant orb of Neptune. So vast is this imposing system, so unimaginable its measurements.

The Nebulous Material in which the Pleiades are Embedded

Still, the Pleiades are near enough to afford us much very valuable information, not only with regard to star systems, but also concerning the relations between stars and nebulæ. The whole group is, as it were, embedded in enfolding nebulous stuff, from which it may perhaps be regarded as having arisen. Wisps, tails, and clouds of nebulous material are apparently attached to various stars of the group, especially to Merope, around which they lie in bars, for the most part parallel with one another; to Maia, in a spiral form; to Electra, in a straight pointed bar directed toward Alcyone; and thickly rolled round Alcyone itself in fog-like clouds. But the nebula is much more comprehensive than these outstanding features would suggest. It involves not only the Pleiades, but a vast region around them on all sides.. Several peculiarly interesting discoveries in regard to nebulæ and stars in general have been made in studying it. For instance, several long threads or ribbons of the luminous cloud-stuff are seen to string together lines of individual stars, uniting them like beads on a string. This seems to prove that lines of stars are really connected, and not fortuitously placed in their rectilinear position. Lines of this kind, either straight, arched, or in beautiful regular loops and festoons, are common features of many clusters; and it had become evident to observers that these arrangements must be the result of real relations, before that opinion was finally established by the nebulous connecting lines in the Pleiades.

The Bridging of the Gap Between Star-Clusters and Nebulæ

Clusters such as the Pleiades, in which a group of stars physically related in a single system is combined with a nebula, seem to bridge the gap between star-clusters and nebulæ. The stars in these clusters have, so far as they have been examined, been found to be of the early or "Orion" type, and may perhaps be regarded as having newly arisen from the "shining world-stuff" in which they are still involved.

The forms of star-clusters are often exceedingly beautiful and interesting. Lines, either straight or forming loops, arches, streamers, or more complicated figures, are traceable in many; a considerable number take the form of a half-open fan; others show by their names the resemblances suggested by their shapes. Thus, we have Præsepe, the "manger," which appears as a feeble cloud of light between two stars both of the fourth magnitude. These two stars were called by early astronomers the "asses." Globular clusters are in many ways distinct from the rest, chiefly by their regularity of form and the usual absence of any real nebulosity. We shall consider them later. Coloured stars are sometimes present, and in some cases various colours combined give great splendour and beauty to a cluster, as in a famous group in the Southern Cross, described by Sir John Herschel as "a gorgeous piece of fancy jewellery."

The Grouping of Star-Clusters in Symmetrical Arrangements

Frequently a bright-coloured star occupies a conspicuous and dominating position in a cluster of undistinguished stars, as in certain clusters which occur in Auriga and in Cygnus. Double stars occupy a central position in a cluster in Perseus. In Gemini is found a cluster containing within it a small, clearly defined cluster of seven or eight stars very close together. In Auriga there is a cluster in the form of a cross; on each arm there are two particularly bright stars, distinguished above all the rest.

Similar devices of symmetry or effective placing are frequent. Well-defined geometrical forms, such as triangles and rectangles, are by no means uncommon.

Globular clusters are in general much more sharply defined than are the various irregular forms considered above. Occasionally the edges of the globe are clean and entire, but more often they are radiated by outward streamers and thread-like appendages, suggestive of an outward flow from the cluster, as if it might be a nest of bright new suns to be sent out gradually to occupy the spaces of the heavens. This may, in fact, be in some sense a true account of them, but it is certainly too early in the history of their observation to allow of any definite theory of this kind.

Very beautiful indeed are these wonderful balls of suns when seen in a great telescope. One of the most perfect is found in the constellation Centaur, where it appears to the naked eye as a rather blurred fourth-magnitude star. In a good telescope this star becomes transformed into a vast sphere of brilliant, glorious suns, of which over five thousand have been counted by photographic means.

A similar but smaller cluster in the Toucan is even more closely packed with bright suns, over two thousand being grouped within a boundary line of comparatively small radius. Another famous example is the great globular cluster in Hercules, sending out streamers and tentacles of stars to a distance which nearly doubles its diameter. In all these clusters the thickness of the crowding of stars increases in regular arithmetical progression from circumference to centre. The Hercules cluster is broken, as it were, by three dark rifts or lanes leading outward from a point not at the centre, but to the south-east of it. Suggestions of similar markings, though far less clear, appear in other parts of the cluster, as though some definite law of its being were at work producing this effect. The dark lines are found, however, by photographic means, to be not really devoid of stars. They are strewn with small, faint stars, as, indeed, is the whole cluster, these small, faint stars being disposed apparently in really globular order. But there are also many bright stars, disposed in radial lines stretching outward in curves ; and these are entirely absent from the dark lanes, which no doubt appear dark partly by contrast.

The stars in a globular cluster are usually graded according to brilliancy in an extremely methodical way. The arrangement

A PHOTOGRAPH OF A REGION IN THE PLEIADES, SHOWING ITS NEBULOUS CHARACTER

of smaller stars in the centre, with bright ones scattered over them, which we can trace in the Hercules cluster, prevails also in most, if not all others. A cluster in Sagittarius presents the appearance of a ball of small stars of about fifteenth magnitude, surrounded by a shell of eleventh-magnitude stars. Others elsewhere are similarly composed of stars of two magnitudes, the smaller massed together at the centre, the larger lying over them in curved, radiating lines.

The movements of individual stars in a globular cluster form an interesting subject for speculation, but may in future become the subject of actual knowledge. Clusters have been observed for such a short time that nothing is as yet known of these movements. In 1891, however, Dr. Scheiner, of Potsdam, obtained from a photograph exact measurements of the positions of 833 stars in the Hercules cluster, and these will provide a valuable table of reference for future observations.

The number of variable stars found in globular clusters is very remarkable, and as yet not understood. As many as a hundred have been found in a space in the sky that would be covered by a pin's head held as far away from the eye as it could be distinctly seen.

The Strange Waxing and Waning of Stars in Star-Clusters

The Centaur cluster is an example which is fertile in variables. Out of three thousand examined, nearly one hundred and thirty were found to be variable, for the most part within one and a half or two magnitudes, and sometimes less, down to an extent of half a magnitude; sometimes more, up to one which varied to the extent of five magnitudes. There seems to be no interdependence in the changes of the various stars in a cluster. Each varies apparently on its own account, as if entirely unrelated to its fellows. Miss Clerke thus comments on this extraordinary phenomenon:

"No more curious spectacle is afforded by the heavens than that of a throng of seeming signal-lights waxing and waning every few hours under the sway, obviously, of some common law, yet with no trace of unanimity, some fading while their neighbours are on the rise, others stationary and semi-extinct, though only biding their time to enter upon a phase of renewed brilliancy, and none deviating by a hair's-breadth from the course of change individually prescribed for it."

The Hercules cluster is much more stable in light than the majority of globular clusters, and only two variables have so far been discovered in it. But, on the whole, variability is a common feature of cluster stars. It is of a special type, consisting in long quiescent periods of comparative dulness, with short and quickly attained periods of brilliancy, the whole recurrent period being usually very short, and often measured in hours. For example, eighty-five variables have been discovered in a very fine cluster in Libra, almost all of which have a period of about twelve hours, although without any apparent order in the times of occurrence. No physical differences, so far as can be ascertained, distinguish clusters rich in variables from those whose stars shine steadily.

The Variation in the Appearance of Star-Clusters Determined Largely by Distance

The stars composing the various clusters are no doubt of different sizes, and are packed with different degrees of closeness. But at least a part, and probably a considerable part, of the differences which give to one cluster the appearance of a heap of fine sand, and to another a coarse-grained appearance as of much larger particles, is due to a difference of distance from the earth. For the same reason it is probable that many very distant clusters escape recognition, because they present the appearance of nebulæ.

We have already referred to the relations between star-clusters and nebulæ. These two kinds of structure not only approach one another in form by insensible gradations, but, as may be seen in the case of the Pleiades and of hundreds of other irregular clusters, they are also found together, merged in one another and united in a manner which leaves little doubt as to the evolutionary nature of their relation.

The Evolutionary Nature of Nebulæ and Star-Clusters

We can hardly doubt that at some point of development the white star emerges from the nebulous stuff, perhaps remaining embedded in it until the whole of the faintly luminous material has coalesced into the form of stars, as in globular clusters; and after this it is conceivable that a centrifugal action arises by which the clustered stars are gradually driven out from their nest to occupy the spaces of the heavens as independent suns. But all this, as has been said, is purely speculative.

The study of nebulæ is most fascinating, and is likely to prove very illuminating. It is remarkable that almost all forms and conditions of stellar existence have their close

parallels in nebular existence, though of course in a vague and shadowy manner. Thus we have nebulous stars and planetary nebulæ, double nebulæ answering to double stars, variable nebulæ, and there are even two great classes of elliptical and irregular nebulæ, corresponding to the globular and irregular forms of star-clusters.

Nebulæ abound in the heavens, and assume all kinds of odd and beautiful forms. There are tails, brushes, wisps, rings, fans, rays, triangles, squares, discs, spheres, and many other shapes, but almost all hidden from unaided vision. The only one which is easily discernible is the great nebula in Andromeda, illustrated on pages 18 and 520.

The Most Easily Seen and Historical Nebulæ in Andromeda

This is the supreme example of the regular or elliptical form of nebula, and was well known to Al Sufi, the Arabian astronomer, in the tenth century. Nebulæ of this form are called by Professor Young "white nebulæ," as distinguished from gaseous nebulæ, such as the great irregular nebula in Orion (see page 521) and others of similar type. White nebulæ give a continuous spectrum, and are probably of quite different constitution from gaseous nebulæ. Their forms are usually quite definite, and brighten progressively from circumference to centre, often condensing finally in a small nucleus similar to that of a comet. Dark curved bands, following the form of the ellipse, frequently intercept the disc of elliptical nebulæ; and a careful study of these bands, and of the dark lines or rifts in the various white nebulæ, has proved that all of them are essentially spiral in structure, though the appearance varies according to the inclination at which we see the nebula. A very comprehensive survey of these nebulæ was made by Professor Keeler with a view to establishing this principle, and the results which he obtained have left no doubt in the matter. About one hundred and twenty thousand nebulæ were observed by means of photography, and the traces of spiral formation were visible in almost all this immense number of photographs. (See pages 20, 25, 1141, and 1143.)

The Clearest and Most Beautiful of the Spiral Nebulæ

The various forms which are assumed are often very beautiful. The spiral is often double, two diametrically opposite branches being thrown outward from a central nucleus, sometimes in the direction of a second nucleus which is finally reached by one of the branches. The clearest and most beautiful specimen of this type is a nebula in Canes Venatici, called, from its appearance, the Whirlpool nebula. Two streams of luminous matter proceed from the nucleus at opposite points, and circle about it in spiral form in the direction in which the hands of a clock travel. Both of these arms are uneven, and full of thick patches and bosses; they divide and again unite; and they give off tails which are turned away from the nucleus, like the tails of comets. One branch dies away to nothing; the other and longer gains a second nucleus at some little distance, after executing a complete curve about the primary nucleus. The whole appearance of the nebula suggests the combined effect of repulsive and rotatory forces, and has striking analogies with the structure of comets. The peculiar clearness of the Whirlpool nebula is due to the fact that to our vision it is scarcely foreshortened at all. In some nebulæ the spiral takes the form of the letter S, of which a good example is found in Pegasus. In this case, only parts of the complete spiral could be seen by means of the telescope, and various observers gave it very different forms, but its double spiral was revealed as soon as photography was applied.

The Theory of Kinship Between White Nebulæ and Globular Clusters

Almost all white nebulæ, with their spiral structure, are more or less globe-like bodies, and the theory that they are related to globular clusters has suggested itself to many observers. They all glow with continuous light. Their spectrum has not yet been satisfactorily interpreted, but it appears to support the theory that white nebulæ are, in fact, star-clusters, situated at such a distance that the light of their individual stars has become merged into a faint haze of soft light. Several difficulties, however, stand in the way of this theory. In the first place, the light is so faint that if the extensive clusters of nebulæ do indeed represent clustered stars, these stars must be at enormous distances apart. Moreover, if the light be due to merged starlight, the stars must be many times further apart in the fainter regions of the nebula, and in that case the wider scattering should produce a different texture, and the individual stars should become separated to our view. But this never happens. The texture of nebular light appears exactly the same in all grades of brightness. The cluster theory of white nebulæ is therefore far from easy of acceptance.

Gaseous nebulæ are far less numerous

than white nebulæ, in the proportion of less than one to a hundred. They are all of irregular shape, of large size, and of ill-defined outlines. Only parts of them become apparent to direct vision, even in large telescopes; but the dimmer parts and outer regions impress themselves easily on photographic plates, showing that their light is of far greater actinic than it is of visual power. It may almost be said that each irregular nebula is of a class apart, for they all display strong individual characteristics. Thus, the dominating feature in the great Orion nebula, sometimes called the "Fish-mouth," is a trapezium of bright stars with a bright central region about it.

Features of the Great Irregular Nebulæ—the "Fish-mouth" and "Keyhole"

In the second greatest, the nebula in Argo, known as the "Keyhole," the most prominent feature is a sharply defined black opening, which has given its name to the nebula, gaping right in the centre of its brightest part. The Trifid nebula, in Sagittarius, is dominated by a bright multiple star situated just at the inner edge of one of the three petal-like lobes from which the nebula takes its name.

The most famous and resplendent of irregular nebulæ is undoubtedly the great Fish-mouth in Orion. It may be seen with an opera-glass as a silvery cloud round a multiple star in the sword of Orion. It was first attentively studied by Huygens in 1656, and from him the central bright part forming the so-called Fish-mouth became known as the "Huygenian region."

One of the stars of Orion is seen, by the aid of the telescope, to be multiple. The four chief component stars which constitute it form a trapezium, which is, as it were, the hub of this whole great nebula. These stars are of the fifth, sixth, seventh, and eighth magnitudes respectively, and they are very close to one another.

The Part of the Heavens Named after a Dutch Watcher of the Skies

They are actually embedded in the nebulous matter, as is confirmed by the spectrum of the multiple star, which shows very close nebular affinities. These stars have a small proper motion corresponding, at their computed least distance of a thousand light-years, to a real motion of about fifty miles a second; and it seems certain that the nebula shares this motion.

Photographs of this great nebula are very beautiful and impressive. The Huygenian region forms roughly a right-angled triangle, the base of which is broken to form the mouth of the sky-monster. It is most sharply defined along this edge, but with increasing photographic power this outline, too, becomes softened in vast clouds of fainter and far more extensive nebula. The whole formation has probably by no means been yet revealed, for its boundaries extend further with every new improvement in the instruments of research. It holds a central position in a wide region abounding in nebulæ, and it is likely that these will be found to be connected. At present the limits of the great nebula include a considerable portion of Orion's body. A large curved nebular cloud sweeps round the belt, and the Fish-mouth within it, and already distinct traces of a spiral principle working on an enormous scale have become evident in the whole.

The colour of the nebular light is faintly green, and the Fish-mouth has an unearthly appearance when viewed in a good telescope. The mouth is the centre of apparent nebulous rays running out from it in all directions, in forms strikingly like the rays of the solar corona; and these effluences go to make up the outer parts of the nebula. The close similarity of form between the corona and the great nebula is rendered the more significant by the fact that hydrogen and helium are found together in the spectrum of both, whereas in starlight, as one of these gases appears, the other always disappears from the spectrum.

The Strange Colours of the Great Irregular Nebulæ

All the irregular nebulæ have the same strange, greenish tinge. The Keyhole nebula in Argo, mentioned above, is a magnificent object, following as it does a procession of peculiarly bright and numerous stars. It extends over more than a square degree of the heavens, and more than twelve hundred stars are seen projected upon it. Some of these, if we may judge from the significant positions in which they occur, must be actually situated within the nebula. In the centre and very brightest part of the nebula is a black opening in the shape of a keyhole, and exactly upon the edges of this dark cavern are seated four bright stars. No stars whatever can be seen within the keyhole.

It is often not easy to say whether an object should be regarded as a star with filmy appendages or as a nebula with a stellar nucleus. A true nebular star is surrounded by a luminous halo which cannot properly be called an atmosphere, since it is both self-luminous and inordinately

extensive. Thus, the halo of the first nebular star to be discovered is of an extent sufficient to fill a space twenty-seven thousand times greater than that contained within the orbit of Neptune. The stellar nuclei are often compound. A star in Auriga consists of three stars set in the form of an equilateral triangle, placed exactly in the centre of a small circular nebula. Another in Orion consists also of three stars, respectively yellow, purple, and white, embedded in a nebulous halo.

Nebulous stars with compound nuclei are connected by transitional forms with double nebulæ. Increasing instrumental power tends, however, to merge nebulæ, formerly supposed to be double, into single nebulæ; whereas stars formerly supposed to be single are more and more divided into compound systems by the advance in optical efficiency. Yet the clearly defined double nuclei in the spiral nebula in Canes Venatici, referred to above, and others of similar constitution, lead us to a belief in the real existence of double nebulæ. Sir John Herschel made a special search for these objects, holding that they might represent the early stages of double stars. Compound nebulæ have been found in all combinations similar to those of double stars. Thus, we find a single primary nebula with two satellites; a single satellite attending two primaries; three fairly equal companions; doubles of various forms, such as elliptical, globular, lenticular; and other combinations. A curious example in Pegasus consists of three small nebulæ placed at the angles of a triangle whose sides are sketched by filmy nebulous bands, and in the midst of this figure is a bright double star.

THE ANNULAR NEBULA IN LYRA
From a photograph taken by Mr. G. W. Ritchey

Planetary nebulæ usually appear elliptical in shape, and are probably really spheroids. They contain a stellar nucleus situated apparently within a disc, the latter having a more or less complicated form often suggesting the envelopes in the head of a comet. The largest of planetary nebulæ, known as the "Owl," was described by the younger Herschel as "a large, uniform, nebulous disc, quite round, very bright, not sharply defined, but yet very suddenly fading away to darkness." Later, two stars were observed within it, each in the centre of a dark cavity, with a bridge of luminosity between them, giving to the whole a singular likeness to the face of an owl. But the stars have since become invisible, being replaced by a single bright star on the central bridge of light, and dominating the whole nebula.

Annular nebulæ are often very beautiful. The most perfect, situated in Lyra, appears as a hoop of filmy light surrounding a star. The hoop is neither even nor circular. It is oval in form, and brightest at the extremities of its shorter axis, fading considerably at the ends of the longer axis. Photography shows the centre to be covered with a filmy veil, and it is believed that the ring is the effect of a tenuous globe seen in perspective, through which the central star shines unobscured.

It is expected that knowledge of the nature of nebulæ will be gained principally by the spectroscope. The general results of spectroscopic study have revealed conditions of great rarefaction and of very low temperature. It is also known that nebulæ are of excessive tenuosity, because of their enormous volume, together with their inability to produce large velocities in the stars in their vicinity.

Calculation has shown that the Orion nebula, at the lowest estimate of its size, if composed of matter one million times rarer than our atmosphere, would be capable of producing great velocities in all stars near it. But no sign of any such effect is found among all the stars of the region; indeed, the stars about Orion are singularly fixed. The density of this nebula must therefore be immeasurably less than the density of air in a vacuum tube. We cannot tell whether nebulæ consist of minute, widely separated bodies, or whether they are of a continuous nature; and the nature of their light is equally elusive. We only know that they are some kind of feebly luminous, cosmic fog.

A LIFE-RUSH FROM A VESUVIAN MUD-FLOW

A SCENE IN SAN SEBASTIANO, NEAR NAPLES, DURING THE ERUPTION OF 1906

VOLCANIC CATASTROPHES

The Story of the Great Historic Surprises from Vesuvius, Bandaisan, Krakatoa, Mont Pelée, and Mauna Loa

SCENES WHEN FIRE RAINED FROM THE SKY

In the last chapter we described the general phenomena of volcanic eruptions; we will now give brief accounts of some of the great volcanic catastrophes.

One of the most notable eruptions of historical times was the terrible outburst of Vesuvius in 79 A.D.—the eruption that buried the great cities of Pompeii and Herculaneum. For centuries the monster had slumbered. A hundred and fifty years before the great eruption, the gladiator Spartacus, with seventy followers, took refuge in its crater, and, when besieged by Clodius, escaped by climbing down mountain vines. No one thought of the mountain as a volcano, unless, perhaps, a few observant men, such as the historians Strabo and Diodorus Siculus, who noticed the cindery aspect of the surrounding country. Up almost to the crater of the volcano were fields, vineyards, orange groves, and prosperous villages, and at its base were the cities Herculaneum and Pompeii, with their villas and palaces, their theatres and temples. No dread o eruptions disturbed the inhabitants of this happy land, which basked in the sun and "laughed fertility." Yet they had many warnings before the dire disaster. The monster stirred in his sleep; his great flanks heaved; the land was shaken with earthquakes. For sixteen years these earthquakes occurred, till, finally, a great earthquake, on August 24, 79 A.D., was followed by the great eruption.

The historical documents describing the eruption are, of course, the famous letters of Pliny the Younger, and we cannot do better than quote part of a letter to Tacitus.

"Being got at a convenient distance from the houses, we stood still in the midst of a most dangerous and dreadful scene. The chariots which we had ordered to be drawn out were so agitated backwards and forwards, though upon the most level ground, that we could not keep them steady, even by supporting them with large stones. The sea seemed to roll back upon itself, and to be driven from its banks by the convulsive motion of the earth. It is certain at least the shore was considerably enlarged, and many sea animals were left upon it. On the other side a black and dreadful cloud bursting with an igneous serpentine vapour darted out a long train of fire, resembling flashes of lightning but much larger. . . . The ashes now began to fall upon us, though in no great quantity. I turned my head, and observed behind us a thick smoke, which came rolling after us like a torrent.

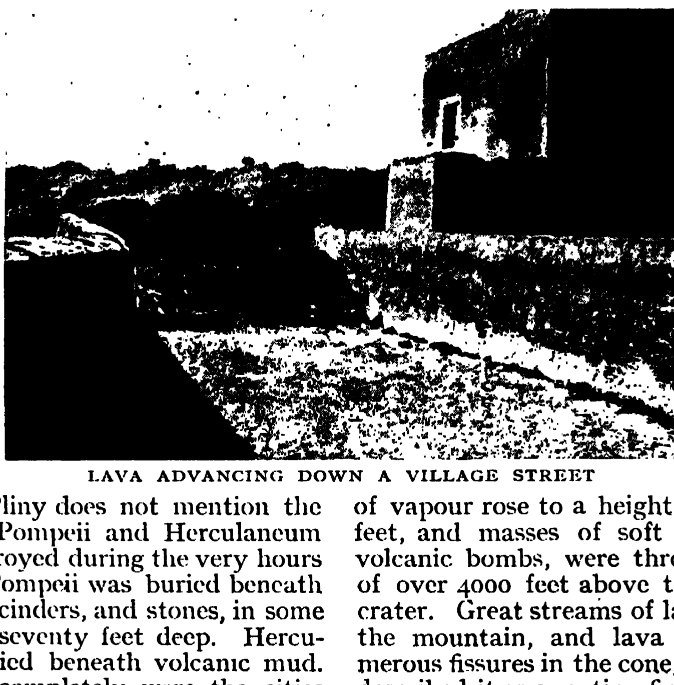
"I proposed, while we yet had any light, to turn out of the high-road, lest we should be pressed to death in the dark by the crowd that followed us. We had scarce stepped out of the path when darkness overspread us, not like that of a cloudy night, or when there is no moon, but of a room when it is shut up and all the lights extinct. Nothing then was to be heard but the shrieks of women, the screams of children, and the cries of men; some calling for their children, others for their parents, others for their husbands, and only distinguishing each other by their voices; one lamenting his own fate, another that of his family; some wishing to die from the very fear of dying; some lifting their hands to the gods, but the greater part imagining that the last and eternal night was come which was to destroy the gods and the world together. Among them were some who augmented the real terrors by imaginary ones, and made the frightened multitude falsely believe that Misenum was actually in flames.

"At length a glimmering light appeared, which we imagined to be rather the fore-

runner of an approaching burst of flame, as in truth it was, than the return of day. However, the fire fell at a distance from us, then again we were immersed in thick darkness, and a heavy shower of ashes rained upon us, which we were obliged every now and then to shake off, otherwise we should have been crushed and buried in the heap.

"I might boast that during this scene of horror not a sigh or expression of fear escaped from me, had not my support been founded in that miserable though strong consolation that all mankind were involved in the same calamity, and that I imagined I was perishing with the world itself.

"At last this dreadful darkness was dissipated by degrees, like a cloud of smoke; the real day returned, and soon the sun appeared, though very faintly, and as when an eclipse is coming on. Every object that presented itself to our eyes—which were extremely weakened—seemed changed, being covered over with white ashes, as with a deep snow."



LAVA ADVANCING DOWN A VILLAGE STREET

This is a picturesque and interesting narrative, but strangely enough young Pliny does not mention the destruction of Pompeii and Herculaneum which were destroyed during the very hours he describes. Pompeii was buried beneath layers of ashes, cinders, and stones, in some places sixty or seventy feet deep. Herculaneum was buried beneath volcanic mud. So deeply and completely were the cities buried that during the Middle Ages their very existence was forgotten. It was one of the most terrible catastrophes in human history.

After that great eruption Vesuvius was in an explosive state for many years, but in the seventeenth century it seemed quite dead, and cattle grazed and wild boars had their den within its crater. Again it proved a very lively corpse. Six months of earthquakes in 1631 were succeeded by a terrific eruption, which blew away the whole top of the mountain and scattered ashes for hundreds of miles. Seven streams of lava poured from the crater, and several villages, including the village of Reisna, which had been built over the buried Herculaneum, were destroyed. For the next hundred and fifty years there were constant eruptions great and small, and the mountain underwent frequent alteration in shape and size. In 1794 a great fissure was formed 2375 feet long, and a tremendous torrent of lava ran down to the sea. All through the nineteenth century periodic earthquakes and volcanic paroxysms continued. Altogether, in the eighteenth and nineteenth centuries, Vesuvius was in eruption about fifty times, or about once every two years.

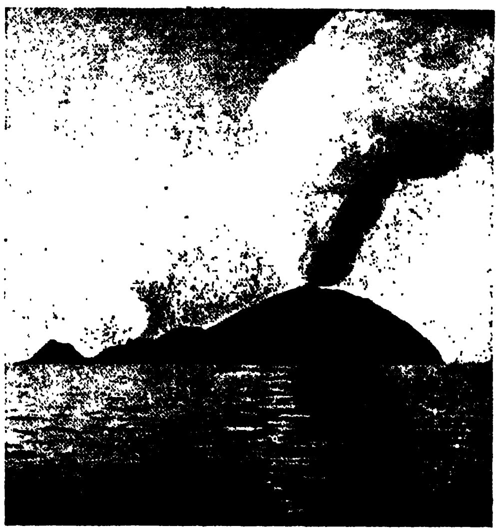
Within quite recent times there have been two great eruptions, in 1872 and 1906. The eruption of 1872 was carefully observed by Professor Palmieri in the Vesuvius Observatory. In all respects it was a typical eruption. It was preceded for some time by earthquake shocks and increased volcanic activity; and then suddenly, on April 24, the great eruption began. On this occasion the column of vapour rose to a height of about 20,000 feet, and masses of soft lava, known as volcanic bombs, were thrown to a height of over 4000 feet above the mouth of the crater. Great streams of lava poured down the mountain, and lava oozed from numerous fissures in the cone, so that Palmieri described it as sweating fire. The lightning flashes in the vapour column were very vivid, and the bellowing and roaring of the explosion could be heard miles away. Several villages were partially destroyed, but most of the inhabitants escaped.

In April, 1906, Vesuvius was in eruption yet again, and six lava streams poured down the mountains. Professor Matteuci, then in charge of the Vesuvius Observatory, reported on April 8: "The eruption of Vesuvius has assumed extraordinary proportions. Yesterday and last night the

activity of the crater was terrific, and is increasing. The neighbourhood of the observatory is completely covered with lava. Incandescent rocks are being thrown up by the thousands to a height of 2400 or even 3000 feet, and, falling back, form a large cone. Another stream of lava has appeared. . . . The noise of the explosion and of the rocks striking together is deafening. The ground is shaken by strong and continuous seismic movements, and the seismic instruments threaten to break."

On April 9 he reported that: "The explosive activity of Vesuvius, which was so great yesterday, and was accompanied by very powerful electric discharges, diminished yesterday afternoon. During the night the expulsions of rocks ceased, but the emission of sand increased, completely enveloping me, and forming a red mass from 6 to 10 centimetres deep, which carried desolation into these elevated regions. Masses of sand gliding along the earth created complete darkness till seven o'clock. Several blocks of stone broke windows in the observatory."

Much more sand and dust were discharged than during the previous eruption, and all the roofs of the houses in Naples were covered with a fine red dust. Vesuvius, therefore, has had a pretty violent past, and no one dare say that its fiery paroxysms are yet over.


STROMBOLI AWAKE

Other well-known volcanoes in the Mediterranean are Etna, Stromboli, Santorin, and Vulcano.

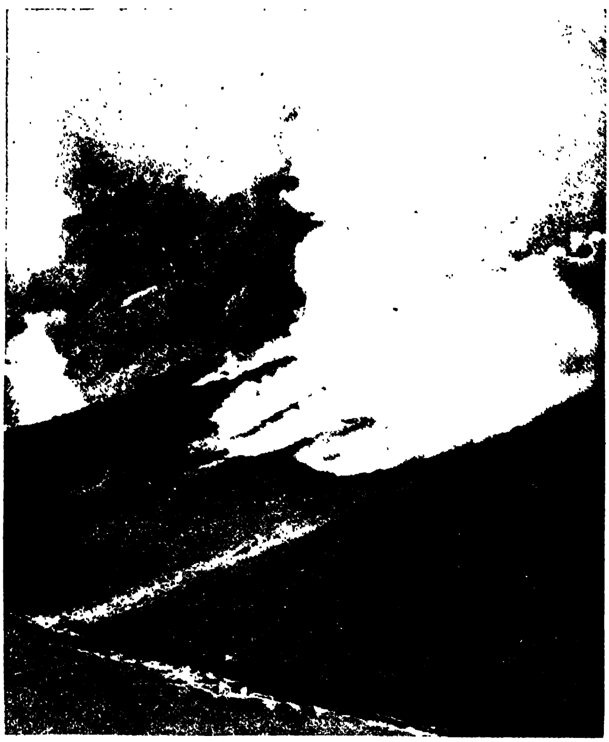
Bandaisan, or Kobandaisan, in Japan, is not so well known as Vesuvius; but this is not surprising, since, for at least a thousand years, it cultivated a masterful inactivity, and peasants worked daily in its green forests without the least foreboding of a fiery doom. Probably there had been small local eruptions during the intervening centuries, but nothing like a great eruption.

Bandaisan, like Krakatoa, is really a group of peaks which are the remains of an ancient colossal volcano, and, according to tradition, the original massive mountain was split up by a great explosion which buried fifty villages; but so dormant had volcanic energy been since that time that at the time of the recent catastrophe a forest occupied the site of the ancient crater.

The last terrific explosion took place on July 15, 1888. There were a few rumblings, a severe earthquake, and then suddenly a dense column of steam and dust shot into the air. Explosion followed explosion, darkness shot through with lightning covered the land, and then a mighty avalanche of mud, earth, and rocks rushed and crashed down the mountain, burying villages as it went, and devastating an area of 27 square miles. Isurumaki, a Japanese priest, who had a miraculous escape from death, gives the following interesting account of his experiences: "The morning of the 15th, which was the fatal day, dawned with a bright and pleasant sky. . . . At about eight o'clock, however, there was a fierce convulsion of the ground, and we all rushed out of the house. In about ten minutes, while we were fearfully wondering what was the matter, a terrible explosion suddenly burst out from the slope of Kobandai, about a quarter of a mile above a place at which steam had been issuing from time immemorial. This was followed by a dense mass of black smoke, which ascended into the air, and immediately covered the sky. At this time showers of large and small stones were falling all about us. To these horrors were added thundering sounds, and the tearing of mountains and forests presented a most unearthly sight, which I shall never forget as long as I live. We fled in all directions, but before we had gone many yards we were all thrown prostrate to the ground. It was pitch dark; the earth was still heaving beneath us; our mouths, noses, eyes, and ears were all stuffed with mud and ashes. We could neither cry out nor move. I hardly knew whether I was dead or in a dream. Presently a stone fell on my hand, and I knew that I was wounded. Imagining that death was at hand, I prayed to Buddha. Later I received wounds on my loin, right foot, and

back. After the lapse of an hour the stones ceased to rain, and the atmosphere had cleared from darkness to a light like moonlight. Thinking this a fine opportunity to escape, I got up and cried, 'Friends, follow me!' but nobody was there. When I had descended about half a mile, there was a second explosion, and a quarter of a mile further on a third explosion, and ashes were ejected, but no stones."

The most striking feature of this explosive eruption was the immense amount of earth and stones that was discharged, and the immense amount of earth and stones that came down like a landslip without actually being discharged into the air. The mountain was simply pulverised. Part of it was hurled into the air, and part of it slid down like an avalanche of mud, earth, and rocks. There was not much mud; the avalanche was mainly earth and rocks, with here and there huge boulders. As is usual in volcanic explosions, a great quantity of dust was shot forth, and covered the country for miles.


THE STEAMING SLOPES OF BANDAISAN, JAPAN

The total amount of solid matter strewn over the country amounted to something like 1587 millions of cubic yards. It filled up all ravines and gorges, engulfed all familiar landmarks, dammed up several rivers, converted twenty-seven square miles into a desert, and buried four villages, and partly buried seven more. So completely were four villages buried that no one can tell where they are buried. The loss of life was comparatively small; only 461 lives were lost, including 92 who fled from a safe hamlet and were all struck down within a few yards.

An interesting feature of the eruption were the terrible blasts of air driven before the explosions of steam. Houses were levelled, and trees were torn up or stripped of leaves and branches and left standing bare as telegraph-poles. In some places thousands of trees were blown down. Another interesting feature was the multitude of conical, basin-like holes made in the ground by falling stones. We have not space here to describe these in detail.

The great eruption of Krakatoa requires special mention, for it is probably the greatest eruption in historical times. The volcano of Krakatoa is on an island which lies in the Sunda Strait, between Sumatra and Java, a strait connecting the China Seas with the Indian Ocean, which is traversed yearly by hundreds of vessels. The island, along with several others, is the remains of an ancient volcano which was probably about 10,000 feet high, and had a crater about twenty-five miles in circumference. For more than two hundred years the island had rested from its volcanic labours; it was covered with rich vegetation and dense forests. Then, in 1880, earthquakes began, and they were no slight tremors, for they were felt as far off as Northern Australia. On May 20, 1883, the eruption proper began with sounds like the firing of artillery, which were loud enough to be heard a hundred miles away. Next day ashes were sprinkled on both sides of the straits. On May 26 an excursion party from the mainland visited the islands, and found them covered with a white dust like snow, while from the summit of a crater a column of vapour 10,000 feet high was rising into the air, and scattering showers of dust and pumice-stone. All through June, July, and August this state of affairs continued, till finally, on August 26 and 27, the culmination of the eruption was reached.

As we have said, the Sunda Straits are on the route of trading vessels, and captains and passengers of ships on the spot at the time have given us most information of the final catastrophe. Captain Wooldridge, of the "Sir R. Sale," writes that on the 26th the sky presented "a most terrible appearance," and that the cloud above the mountain presented the appearance of an immense pine-tree, with the stem and branches formed of volcanic lightning. After sunset the cloud looked like a "blood-red curtain with edges of all shades of yellow," and lightning zigzagged through it. Captain Watson, of the "Charles Bal," tells of chains of fire that ascended into the sky, and of "balls of white fire" which continually rolled down the mountain. During the great outburst startling electrical phenomena occurred. A peculiar pinky flame came from the clouds and balls of fire studded the mastheads and yardarms of the "Sir R. Sale" and "Charles Bal." The mainmast conductor of the "G. G. London," forty or fifty miles away, was struck by lightning five or six times, and "the mud rain which covered the masts, rigging, and decks was phosphorescent, and on the rigging presented the appearance of St. Elmo's Fire." The natives were so busy putting out the phosphorescent light—which they thought the work of evil spirits—with their hands that the Europeans were left to drive the machinery for themselves.

The whole of Aug. 27 the vessels, the "Charles Bal," the "Sir R. Sale," the "Northam Castle," and the "G. G. London," were in pitch darkness, and under a continual rain of pumice-stone and dust. So violent were the explosions that they were heard three thousand miles away, and they caused some of the most tremendous air-waves that have ever been known. Windows were broken, walls were cracked, lamps were overthrown, gas-jets were extinguished a hundred miles away, and some air vibrations travelled several times round the globe. The immense mass of mountainous material which fell into the sea caused a great wave to rush on to the land at the rate of nearly four hundred miles an hour, and towns and villages were devastated, two lighthouses swept away, and 36,380 people drowned.

A PHOTOGRAPH OF KRAKATOA TAKEN ON MAY 27, 1883
Reproduced from "The Eruption of Krakatoa," by permission of the Royal Society.

The Rev. Phillip Neale, one of the few survivors of the town of Anjer, which was overwhelmed by the sea, gives the following interesting account of his escape. He says "About six a.m. I was walking along

the beach. There was no sign of the sun, as usual, and the sky had a dull, depressing look. Some of the darkness of the previous day had cleared off, but it was not very light even then. Looking out to sea, I noticed a dark, black object through the gloom travelling towards the shore. At first it seemed like a low range of hills rising out of the water, but I knew that there was nothing of the kind in that part of Sunda Strait. A second glance—and a very hurried one it was—convinced me that it was a lofty ridge of water many feet high, and, worse still, that it would break upon the coast near the town. There was no time to give any warning, and so I turned and ran for my life. My running days have long gone by, but you may be sure I did my best. In a few minutes I heard the water, with a loud roar, break upon the shore. Everything was engulfed. Another glance around showed the houses being swept away and the trees thrown down on every side. Breathless and exhausted, I still pressed on. As I heard the rushing waters behind me, I knew that it was a race for life. Struggling on, a few yards more brought me to some rising ground, and here the torrent of water overtook me. I gave up all for lost, as I saw with dismay how high the wave still was. I was soon taken off my feet, and borne inland by the force of the resistless mass. I remember nothing more till a violent blow aroused me. Some hard, firm substance seemed within my reach, and, clutching it, I found that I had gained a place of safety. The waters swept past, and I found myself clinging to a cocoanut palm-tree. Most of the trees near the town were uprooted and thrown down for miles, but this one, fortunately, had escaped, and myself with it.

"The huge wave rolled on, gradually decreasing in height and strength until the mountain slopes at the back of Anjer were reached, and then, its fury spent, the water gradually receded and flowed back into the sea. The sight of those receding waters haunts me still. As I clung to the palm-tree, wet and exhausted, there floated past the dead bodies of many a friend and neighbour. Only a mere handful of the population escaped. Houses and streets were completely destroyed, and scarcely a trace remains of where the once busy, thriving town originally stood. Unless you go yourself to see the ruin, you will never believe how completely the place has been swept away. Dead bodies, fallen trees, wrecked houses, an immense muddy morass, and great pools of water are all that is left of the town where my life has been spent."

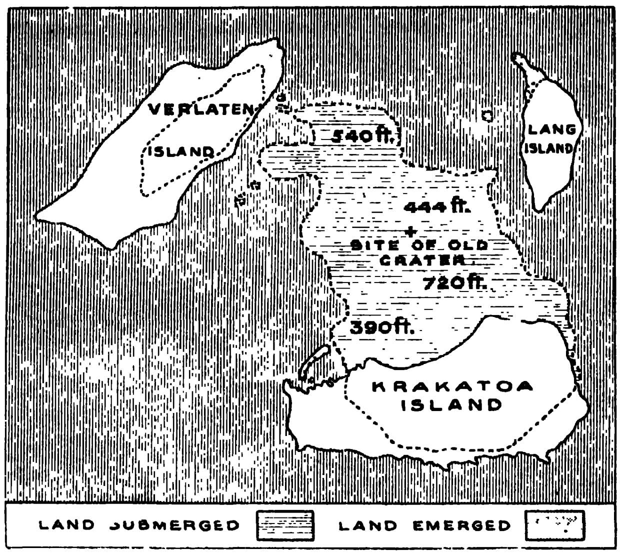


DIAGRAM ILLUSTRATING THE CHANGES WROUGHT BY KRAKATOA ON THE SURFACE OF THE EARTH

The dust of the explosion was unusually fine, was carried to unusually great heights, and gave rise to marvellous sunsets and sunrises all over the world. The Hon. Rollo Russell described the sky at Cannes on January 10, 1884, as follows. "Orange ordinary glow in S.W. near horizon; above this a greenish-bluish white arc, then a beautiful yellow band; then, up to the zenith, a very beautiful lilac tint. All these colours were of extreme softness, and, though not so striking as some of the sunsets in December, in point of beauty they were quite unsurpassable and of superb magnificence in their further progress. The pink, purple, or lilac now retired in the most steady and regular manner towards the horizon, and were visible to the end; thirty-five minutes after sunset the arc was formed of the inner part, which from steel-blue had gone through olive-green to yellow, the middle yellow, and the outer purple. Through the fringe of this Venus shone beautifully. The horizon—about a quarter of the circle—was deep yellow. The purple part being the smallest was flooded, except at the edge, by the orange light, which shone in a grand arc for a long time with great splendour, casting shadows. In

about fifty-four minutes the primary glow was gone, having sunk in a deep red band. The eastern sky during the first part of the display was a glorious deep blue, then very dark purple-blue, and, lastly, only illumined by the silver moon."

Monsieur de Montessus wrote from San Salvador, in Central America, "The remarkable sunsets have been seen here since the last days of November, 1883. About half an hour after sunset, and an hour before sunrise, the horizon is gradually illuminated with a magnificent coppery-red tint, very constant in colour, very intense, and lasting on the average twenty to twenty-five minutes. The moon, when circumstances allowed of it—that is, when her altitude did not exceed 15 degrees—was coloured a magnificent emerald-green, and it was extremely beautiful to see it at the time of grey light, when its disc was of a pale green, with its crescent horn deep green in the midst of an immense crimson curtain. Venus only was able to penetrate the curtain, and was also green."

Not only were there green moons, but also blue and green suns. On September 12, 1883, a Government official wrote from Ceylon: "The sun for the last three days rises in a splendid green, when visible—*i.e.*, about 10 degrees above the horizon. As he advances, he assumes a beautiful blue, and as he comes further on looks a brilliant blue resembling burning sulphur. When about 45 degrees it is not possible to look at him with the naked eye, but even when at the zenith the light is blue, varying from a pale blue to a light blue later on, somewhat similar to moonlight, even at midday. Then, as he declines, the sun assumes the same changes, but *vice versa*. The moon, now visible in the afternoons, looks also tinged with blue after sunset, and, as she declines, assumes a very fiery colour 30 degrees from the zenith."

A STEAMER CARRIED INLAND BY KRAKATOA'S TIDAL WAVE

Krakatoa was certainly in some respects a unique eruption, but as a tragedy it is not to be compared with the eruption of Mont Pelée, in 1902. The island of Martinique, on which Mont Pelée is situated, was one of the most beautiful of the West Indian Islands, and St. Pierre, its chief town, was considered by Lafcadio Hearn "the quaintest, queerest, and the prettiest withal, among West Indian cities." The island was a tropical paradise basking in blue seas, and clad from head to foot in luxuriant vegetation. Even Mont Pelée, though its name signifies bald, had no bare spot in its greenery, for the old crater on its summit had become a beautiful mountain tarn surrounded by ferns and lobelia.

For some time before the dire disaster of 1902, Mont Pelée had been threatening danger. During all April steam was seen issuing from a valley on the shoulder of the mountain, and on the 25th there was a slight discharge of ashes, and an exploring party found that an old dry lake was filled with water. On the 30th there were earth tremblings and slight explosions. All these were warnings of impending danger, but the light-hearted inhabitants had little fear, and their chief paper, "Les Colonies," advertised an excursion to the summit of the mountain on May 4, saying, "If the weather be fine, the excursionists will pass a day that will be long kept in pleasant remembrance."

On May 2, however, there was a violent eruption with loud explosions, and dense steam, and the people began to take alarm, and schools and stores were closed. Soon the streets and gardens were white with falling ashes, and birds dropped dead, poisoned by poisonous gases. Nothing disastrous happened, however, till the 5th, when the side of the new lake we have mentioned was blown out, and its water, rushing down the side of the mountain, carried away trees and rocks, overwhelmed with a river of mud a big sugar-mill and thirty persons in it, and finally plunged into the sea with such momentum

THE FIRE-SWEPT SHIP THAT ESCAPED FROM THE DEVASTATING BLAST OF MONT PELÉE

A PHOTOGRAPH OF MONT PELEE THREE DAYS AFTER THE GREAT OUTBREAK OF MAY, 1902, SHOWING THE "RORAIMA" LYING OFF ST. PIERRE

that it raised a tidal wave that sunk two yachts, and flooded the lower streets of St. Pierre. Then the alarm of the people grew to a panic, and crowds fled from St. Pierre to Fort de France. "It was a flight for safety," says "Les Colonies," "without knowing where to turn. Shop-girls were fleeing with bundles, one with a corset, another with a pair of boots that did not match, and all in burlesque attire which would have evoked laughter had the panic not broken out at so tragic a moment."

The Few Moments that Changed a Busy Town to a Cinder

But they did not flee too soon; death was at their heels. At 7.50 on the morning of May 8, the mountain exploded with deafening detonations, and a black cloud rolled down upon St. Pierre. In a few moments St. Pierre was ablaze, in a few moments more thirty thousand bodies lay dead in the burning town. Captain Freeman, of the "Roddam," who watched the terrible tragedy from the sea, saw a few forms running distractedly upon the beach, but death soon caught them, and the "quaintest, queerest, and prettiest of West Indian cities" was a city of the dead—a blazing, thundering charnel-house. Torrential rains followed the eruption, and, as Heilprin eloquently puts it, "At the end of this time the city was laid in smouldering ruins, coated with ash-paste, and looking as if built of adobe plaster. What had before been the vivid colouring of houses of the tropics was now an ashen grey—the colour of earth, cold, bleak, and burned."

So thoroughly had death done his work that only one man in the whole city survived. This sole survivor was a negro criminal of the name of Auguste Ciparis, who, at the time of the eruption, was in the dungeon of the city gaol.

The Strange Fate that Left Alive One Criminal Negro

He said that when he was waiting for breakfast, on the morning of May 8, hot air, mixed with ashes, suddenly came through the grating and burnt him, so that he could smell flesh burning, and so that he jumped and shrieked with agony. The intense heat lasted only for a moment, and left him fearfully burned. For four days he lay undiscovered in the dungeon, but on the fourth day he was heard calling for help, and was liberated. It is certainly amazing that this one man should have escaped. "There perished in St. Pierre the governor of the colony and his wife; Colonel Gerbault, chief of artillery, and his wife; the British and American Consuls and their families; twenty-four priests; seventy-one women belonging to Roman Catholic sisterhoods; all the professors of the Lycée except five; all the members of the scientific volcano commission except one; and there survived—one criminal negro!"

No one knows exactly the nature of the cloud that wrought such havoc, but it certainly was hot gas, probably ejected towards the town under tremendous pressure and with a velocity of about 100 miles an hour. It not only slew as it went, but it tore solid houses to pieces "as children's play-houses of kindergarten blocks would be torn to pieces by the discharge of a thirteen-inch gun;" it uprooted great trees, it dismounted heavy guns; it tossed about heavy boulders and colossal statues. Many authorities hold that it was probably a blast of superheated steam, but it may have also contained poisonous gases. Whatever its nature, its force was terrific, its effects devastating.

A Blast that Scorched the Shipping from the Waters

A second blast of the same nature occurred on May 20, and completed the work of destruction, so much so that "it was impossible to determine whether a particular heap of stones, plaster, and débris had been a store, a warehouse, a public building, or a private residence." Not only was the city of St. Pierre demolished in this way, but the blast rushed out to sea and capsized and totally wrecked all the vessels in the roadstead except two—the "Roddam" and the "Roraima." The "Roddam" parted anchor, and eventually reached St. Lucia with twelve of her officers and men dead and ten others severely burned. The "Roraima" had her masts, funnel, bridge, and boats carried away, her decks were swept with stones, pumice, and hot ashes, and she was set on fire. Only two of her passengers survived, and twenty-eight out of her crew of forty-seven men died from burns and shock. Such, then, was the tragedy of Mont Pelée—one of the most terrible tragedies since the world began.

One more volcano, Mauna Loa, must be briefly mentioned. It is situated in Hawaii, and is, in some respects, the most wonderful volcano in the world, and has been called the "King of Volcanoes." It has two craters, each more than seven miles in circumference, and the amount of thin lava they can discharge is almost incredible,

THE RUINS OF ST. PIERRE, MARTINIQUE, AFTER THE BLIGHTING ERUPTION OF MONT PELÉE

ALL THAT WAS LEFT OF ST. PIERRE, THE PEARL OF THE LESSER ANTILLES—A TOWN OF 25,000 INHABITANTS

and exceeds that of any volcano in the world except, perhaps, Skaptor Jókull, in Iceland. The upper of the two craters, which rejoices in the remarkable name of Mokuaweowes, does not overflow, as a rule, but when it does overflow it overflows as a regular deluge—"in cascades of fiery red fluid rock."

The first recorded eruption of Mauna Loa took place in 1789, and consisted chiefly of cinders and sand; but the second recorded eruption, which took place in 1823, discharged a river of lava thirty miles long. In 1840 the lower crater broke forth, and discharged a flood of lava from one to three miles wide and from 12 to 200 feet deep, which journeyed thirty miles in four days, and then leapt as a cataract a mile wide over a basaltic precipice into the sea. For three weeks this "Mississippi of molten material" rushed through the deep valleys into the sea, which boiled and steamed where the fiery river entered it. Fish died in thousands and floated on the sea, which was hot for twenty miles along the coast. Such a glare did the torrent give that fine print could be read all night by its lurid glow, and ships a hundred miles at sea beheld the strange light.

Mighty Outbursts from the King of Volcanoes

In 1855 it broke forth with great violence, and this, according to Dr. Robert Brown, was the most awful eruption on record. A torrent of lava three miles wide rushed down the mountain, spread out on the plain into a lake of from five to eight miles in diameter, and then "divided up into a network of rivers which burnt their way through the forest and leapt precipices in a succession of cataracts and rapids." The ordinary rivers became as black as ink from the quantities of pyroligneous acid that drained into them from the burnt forests, and became unfit for drinking. For eighteen months the molten river of lava rushed along. It was sixty miles in length, and covered ,00 square miles of land with millions of tons of lava.

In 1868 an eruption almost as terrible took place. In the first place an enormous torrent of mud, half a mile wide and twenty feet deep, devastated the land. Then four streams of lava gushed from a fissure nearly a mile long, and, falling in a flood over a precipice 500 feet high, overwhelmed many houses and a hundred people. In 1877, in 1880, and in 1887 other eruptions occurred, all characterised by copious flows of lava. In 1880 a lake of surging fire, several miles in diameter and in places three hundred feet deep, was formed, and from this lake three streams of lava flowed to the sea. The amount of lava discharged during these eruptions must have totalled a tremendous amount—enough to make mountains many times the size of Ben Nevis. Altogether, there can be no doubt that Mauna Loa well deserves the title of the "King of Volcanoes."

The Constant Jarrings and Joltings to which the Earth's Crust is Subjected

The earth is by no means so solid and so stolid as it seems. Its crust may be cold, but in its heart is a prodigious heat. From the time when its molten waves surged beneath the sun it has never been quite *terra firma*. Tremendous, massive changes in the contours of its land and water have continually occurred. Mountains have sunk and risen, seas have waxed and waned, whole continents have appeared and disappeared. Even now the Andes and Scandinavia and Scotland and most of the coral islands seem to be slowly rising, and other parts of the world seem to be slowly subsiding.

But apart from these great, slow, massive see-saw movements, the crust of the earth is subject to more or less sudden vibrations, quiverings, quakings. Constantly the earth is jarred, and jolted, and tugged; twice a day not only its waters but its continents and mighty cities are lifted and let fall by the moon; and no doubt the crust responds to changes of atmospheric pressure, and to the pounding of the tides. Even an explosion of gunpowder, an avalanche, a landslide, a traction-engine, an underground train, can produce appreciable movements of the earth's surface. An explosion of a powder-barge at Erith shook the ground at Cambridge, and an explosion of 10,000 pounds of gunpowder at Mainz was felt more than a hundred miles away. The landslips at Rossberg and the Diablerets made the ground tremble over large areas.

Earthquakes Usually the Grinding of Old Cracks in the Planet's Crust

By means of delicate instruments it is found that even smaller concussions serve to shake the crust of the earth. The tread of a horse or the patter of a rabbit can be recorded.

All tremors of the earth due to natural subterranean concussions are known as "earthquakes." The tremors may be so slight that they merely jingle a little crockery in a few houses, or they may be

so violent as to shake down almost a whole city, but they always properly consist of wave-like undulations produced by subterranean movements and propagated through the solid crust of the earth.

Earthquakes are not easy to explain; and in all countries the first efforts to explain them have been made by the imagination rather than by the reason. Of late years earthquakes have been very carefully studied, and it is now known that they are due to two or three different causes. Slight earthquakes may be caused by volcanic explosion, and by the collapse of rocks in subterranean cavities, but the greater and more destructive earthquakes seem certainly due to fracture and displacement of strata of rocks in the great folds of the earth's crumpled crust. In most cases the actual fracture is of old standing, and the earthquake is due to a movement of the edges of the adjacent fractured strata which may be displaced laterally or vertically with reference to each other. But it must be understood that it is not the actual displacements of the strata that are the earthquake so much as the waves in the crust produced by the jolt and jar of the displacements.

The Extent of Fractures and Their Accompanying Earthquakes

Since the larger and more characteristic earthquakes originate in this way by the displacement of the edges of a crack, the area over which an earthquake is most severely felt naturally takes an elongated form.

Thus, in an earthquake at Carlisle in 1901, the area of greatest shock measured 37 miles by 13 miles, and the area of greatest shock in the Constantinople earthquake of 1894 measured 109 by 24 miles.

Frequently the edges of the fracture take a considerable time to acquire a position of stable equilibrium once they have been set in motion. During the last three months of 1839 there were 143 earthquake shocks at Comrie, in Perthshire; at Gifu, in Japan, there were 3365 shocks recorded in a little more than two years.

In many cases the actual fracture whose displacement causes an earthquake can be traced on the surface for many miles. The fracture that caused the great Californian earthquake of 1906 was traced for a distance of more than 600 miles, and the fracture that caused the great Mino-Owari earthquake of 1891 was traced over hills and plains for more than forty miles. Not only can the fracture be traced, but often the displacement can be detected by the overturning of trees and palings, and roads and buildings.

In a few cases the displacement is of the nature known as overthrust—that is to say, one side of the fracture is driven violently beneath the outer edge of the fracture. The tremendous Assam earthquake of 1897 was probably of this nature.

The fractures whose displacement cause earthquakes usually occur either parallel with great mountain ranges or at right angles to such ranges. This is just what might be expected, since it is natural that the crust of the earth should crack just where it is most corrugated and crumpled.

The Various Gradings of Earthquakes by Seismographs, in Movement and Time

Though the great earthquakes are always of displacement, all earthquakes of displacement are not great earthquakes. We have displacement earthquakes that merely rattle the crockery, as well as displacement earthquakes that shake down whole cities. According to their effects it is possible to grade earthquakes. Thus very slight earthquakes make doors, windows, fireirons, and crockery rattle; stronger earthquakes give a sensation of the floor rising and falling; stronger earthquakes still make pictures, chandeliers, and other suspended objects swing; still stronger jerk down ornaments, vases, etc., till finally we reach shocks strong enough to do damage to buildings.

The movement of earthquake waves can be recorded by means of delicate instruments known as "seismographs," and by means of such records it has been shown that there are really three types of earthquakes. There are simple earthquakes where the waves rise gradually to a climax and then gradually die away again; there are twin earthquakes, where in some part of the disturbed area a second shock follows the first almost as soon as the first has died away; and there are complex earthquakes, in which there are many variations in strength, and change of direction.

The Extraordinary Smallness of Earthquake Movement Sideways or Up and Down

A simple earthquake lasts about four to eight seconds; a twin earthquake lasts about twice as long, while a complex earthquake may last for several minutes.

The extent of the vertical and horizontal movement of the ground during earthquakes has also been carefully measured. To those who experience an earthquake the ground seems to move up and down

and to and fro to an alarming extent; but though the results may be alarming, the range of the movement is really very slight. The side-to-side movement is usually less than an inch, and even in the most violent earthquakes does not exceed ten or twelve inches, while the vertical movement is even less. Small as the movement may be, it is often of very great violence. An earthquake at Riobamba in 1747 jerked corpses out of their graves. An earthquake at Quito in 1797 was said to have flung some of the inhabitants a hundred feet into the air. An earthquake at Port Royal in 1692 tossed people from the market-place into the adjacent harbour.

subjected to a violent earthquake shock it is the part of the city which is buil on loose soil that suffers most severely.

Besides shaking the ground and tumblin down buildings, earthquakes often caus considerable changes in the general con tour of the country, and they may forn great chasms and fissures in the ground During the great Lisbon earthquake of 175 a marble quay with crowds of people on i was engulfed in the Tagus, and a populou village near Morocco was swallowed up.

The sounds which accompany an earthquake seem to vary within very wide limits. Sometimes the sound is a dull booming, so low that it is quite inaudible

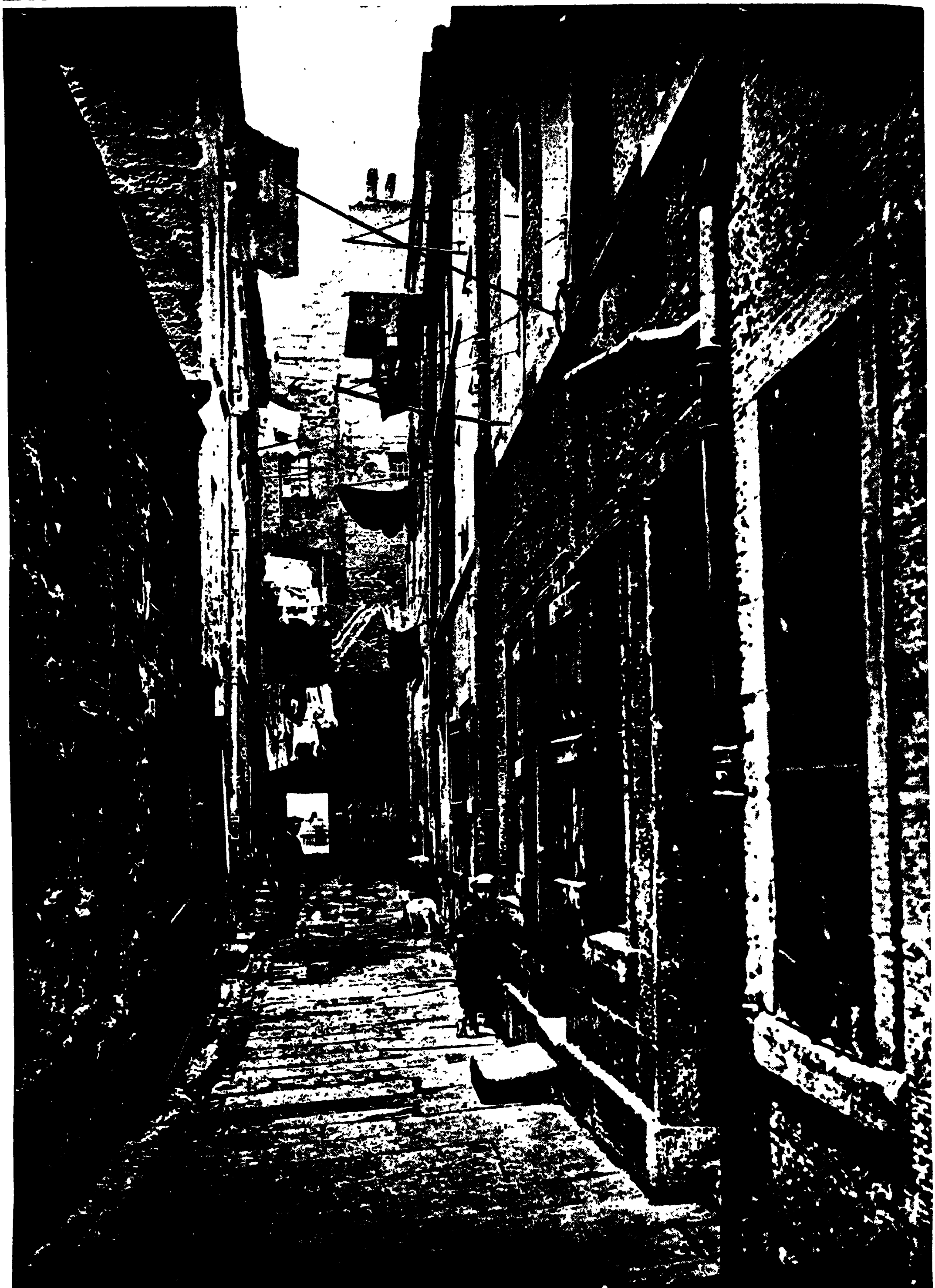
THE SHATTERED SEA-FRONT AT MESSINA AFTER THE EARTHQUAKE OF DECEMBER, 1908

The rate of the earthquake is very variable, and depends to some extent on the material through which it is propagated. The waves produced by the more violent earthquakes may have a velocity of several thousand feet per second, while the waves produced by lesser earthquakes usually travel only a few hundred feet per second.

The nature of the soil necessarily affects the character of the earthquake wave. It is found to be most severe where the soil is loose, and least severe where the soil consists of dense rock. Where a city built partly on loose soil and partly on rock is

to most ears; in other cases it has been compared to the sound of thunder, to the noise of distant artillery, to a deep moaning and groaning, to the bellowing of oxen, to a rushing wind, to the rattling of chains, to the hissing of water thrown on red-hot iron. The distance to which the sound spreads also varies.

In some cases, even when the earthquake has caused great disturbance, the sound has been heard over only a small area, and in other cases where the actual shock has been slight the sound has extended for a considerable distance.



THE AIRLESS, SUNLESS COURTS WHERE THE MICROBES OF DISEASE DESTROY HUMAN LIFE
From a photograph by J. Annan & Sons

CONTROL OF LIFE BY MAN

How the Living Population of the Earth is Being Changed by Man's Activities as Destroyer, Preserver, and Creator

THE FOOD PROBLEM AS MEN INCREASE

LOOKED at from a planetary aspect, plainly all that we have been discussing throughout many past chapters of this section has been the assertion of one form of life, *homo sapiens*, against all others. We have seen that the struggle for life between one species and another is general throughout the living world, and must, indeed, have been one of the great factors of progress. Under the waters of the ocean, in the soil, in the air, on the mountain, in the forest, we perpetually see species struggling with one another, ousting or succumbing to one another, and changing the face of the world accordingly. Man's efforts to establish himself, we see, must be looked upon as similar in principle to those in which the sponge, the starfish, the mould, the monkey, is engaged. He is simply one species struggling for life with and against all others.

But man is so incomparably endowed that the struggle takes on a new aspect where he engages in it. He takes the guise of a conqueror. So skilful is he that, though his birth-rate is extremely low, he yet is the one living species which incessantly, relentlessly, increases in numbers, and must have been doing so for countless ages past. While other species merely manage to maintain their numbers, at best, notwithstanding the enormous numbers of their offspring, man is in a different case. The rest of the living world, where he does not interfere, exhibits what we have called the balance of Nature. After ages of struggle, a balance between the numbers of species has been attained, wherever the environment is constant. Of course, if the environment be altered, the alteration will surely favour one or more species as against the rest, and the balance will require to be readjusted accordingly. But where the environment remains fairly constant, or changes only around a mean, like the climate of our islands, the balance of living species remains very constant, only fluctuating from year to year in accordance with climatic fluctuations.

But to this, which is illustrated in every part of the world, man is the standing and stupendous exception. Though he has inhabited the globe for probably not less than some few millions of years, he has not yet by any means maintained his maximum of numbers, nor has he established any condition of balance with the rest of living Nature. In fact, the idea has not occurred to him. He looks upon himself—not, indeed, without some excuse—as the "lord of the earth," upon all other living things as made for his use and convenience, and he proceeds on his ever-multiplying course without a doubt or a question. So immense are the changes already wrought by the activity of man upon the face of the earth that an observer situated upon the moon with a modern telescope could readily detect them.

All of these changes have involved an alteration of that balance of Nature which obtained until they were effected. Where now a city stands was once forest or field, covered with its own appropriate forms of life, or even a lake or bog, no less rich in the forms of life which can flourish there. Man has expelled them and replaced them by himself. And within the last few decades the nature of his advance has become profoundly modified, thanks to the peculiar instrument he uses, with consequences, achieved and imminent, which it behoves us now to study.

Needless to say, the other forms of life, true to their nature, have always put up what fight they could against the advance of victorious man. An inexperienced observer would naturally expect that the

weakest and smallest forms of life would have been defeated first, and that any outstanding species which man had still to fear would be the largest, the most powerful, and the most intelligent—those which, in the last respect, notably, could fight man to some extent with his own weapons. Nothing of the sort has been the case. On the contrary, the earliest records that we have of man at all are the remains which show that some creature existed which could kill and eat and use the cave-bear and such formidable animals of the past. That creature was man; and we thus find that his mind has always enabled him to gain the mastery over the forms of life which come nearest to him.

The Easy Mastery by Man Over the More Powerful Animals

Wolves roamed, not so very long ago, where now the policeman and the "taxi" occupy the spaces of Belgrave Square; man has defeated them. The possession of considerable intelligence on the part of other animals has never availed them against man, for the gap between the best of theirs and his is too immense. They never had a chance when it came to "brains." Thus the "wild animals," as we call them, have been conquered long ago, wherever man had made up his mind to do so. The struggle for life, as we have seen, has not been between man and the forms of life which most nearly rival him, but between man and the very lowest forms of life, such as the tubercle bacillus, than which no humbler form of living thing is certainly known.

Where some measure of intelligence was unavailing, the methods of the secret poisoner have long succeeded against man, and large tracts of the earth's surface have been held against him in these ways. But the knowledge of which the essentials were obtained in the nineteenth century has changed all that. Intelligence has come to suspect and, lastly, to identify the poisoner.

Man's Growing Mastery Over Secret Poisonous Things

Already man has been enabled to establish himself in large numbers, as in the Panama Canal zone, where formerly he could not survive. The present numbers of our race, perhaps some sixteen hundred millions, must indefinitely increase, it would appear.

But we have forgotten something. The struggle for existence is a fact, and one which man illustrates no less than any other living species; but it is not the whole of the facts. There is also the interdependence of species; and there is no species which more completely demonstrates a dependence upon others than does man.

As an animal in body, he is, like all other forms of animal life, dependent upon the existence of vegetable life, which he is constantly engaged in destroying, and in replacing with his paving-stones and tramway lines; as a mammal, he very largely depends for his survival and health upon milk and the various products of milk; as a species, therefore, he is very largely all but a parasite upon the cow and the goat and the ass. For hosts of other purposes he is dependent upon other forms of life; the existence of a city could not long be maintained without the substances of animal and vegetable origin, such as leather and wood, which man employs. The paper upon which these words are printed was manufactured by man, but it was in the first place manufactured by vegetable life, no less than the original papyrus from which our modern word is derived.

Will Man Conquer His Dependence on Animals and Vegetables?

It is always imaginable, no doubt, that man may learn to make for himself the equivalents or superiors of various animal and vegetable products upon which he depends today. Though as yet "there's nothing like leather," there may be something better some day, and synthetic rubber appears to be achieved. We are not even entitled to say that man's intelligence may not some day enable him to construct proteins, starches, and sugars by transformation of the energy of sunlight, without having recourse to the powers of the green plant. Meanwhile, however, nothing is more certain than that man is destroying other forms of life, and replacing them by himself, with a freedom and to an extent which cannot indefinitely be maintained.

Our own islands illustrate, as never before in the world's history, the extraordinary state of things which the almost unfettered intelligence of man has established. Only a fraction of our food is produced upon our own soil. The balance of Nature has been utterly upset, and we have one species existing in numbers which have no feasible correspondence to the rest of life. This state of things, presented upon our islands, could not, of course, exist upon the whole area of the world. There can never and will never be more human beings than there is food to feed.

Until the day on which man succeeds in deriving all he needs from sunlight directly,

he has to recognise that he can only command Nature by obeying her, and that his career of conquest over other forms of life must be qualified by the fact that he is dependent upon what he conquers. He is hacking at the ladder which supports him, and he must think again. Already, in his great cities, the difficulties of supplying enough food—that is to say, vital products—to his young are so great that they habitually die like flies. It behoves him to recognise the elementary conditions of his tenure of the globe.

Man as the World's Spendthrift and Improvident Heir

So pre-eminent is he in intellect, in the knowledge which is power, that man not unreasonably regards himself as the owner of his planet, of which he proposes to take control, and which he intends to administer as he will. At present he can only be looked upon as a spendthrift and improvident heir of the vast and ancient inheritance which he has lately, having reached his majority, begun to control. Its resources are stupendous, and he goes gaily ahead, not thinking of the morrow. He will not exhaust the sunlight, nor the air, nor the ocean. Let him do what he will, enough and to spare of these will remain. But the other forms of life are not in that category, and he does not know it.

If he wants diamonds, he goes and finds them; if he wants furs, he goes and *kills* their owners and dispossesses them. It is this killing, this taking of life, that stands apart from all the rest of man's activities. He has no idea how murderous he is. He thinks of himself as "civilised," tame, domestic, and gentle. Never in the history of the world was so fierce, so insatiable, so destructive a creature contrived.

Man as the Insatiable Destroyer of what may be Invaluable Life

He takes life, to some extent, for fun, but to an immeasurably greater extent for use; and he simply chooses to forget the conditions on which the supply of such life can be maintained. After us, the deluge, is his motto. Not merely rare and lonely forms of life are disappearing before him, but also forms of life which can be of immense and irreplaceable service to him. He can build motor-cars that beat horses, but he cannot build motor-cars that will supply him with the anti-toxin of diphtheria when the breath of life can no longer enter his choking throat.

We cannot afford to exterminate forms of life on every hand, as we do at present. An ape is only an ape, and man may think it wise and right to replace apes by men; but there are services which the blood and body of the ape, just because it is so near mankind, can perform for our species, and which no other living races can perform. But the apes are rapidly going, and it seems probable that before long they will be extinct. Now, anyone or anything can kill, but creation is not so easy. When auks or apes are once destroyed they cannot be restored, any more than we could restore the dinosaur or the coal-bearing ferns if we wanted to. As things go at present, posterity will blame us, and rightly, for many outrageous pieces of irreparable destruction which we are now committing in our ignorance and carelessness.

If we look properly at human history, we realise that man has been dependent upon the rest of the living world from the first, and that his progress and numerical increase have essentially depended not upon his destruction but upon his *cultivation* of other forms of life.

Man's Triumphs not Dependent on the Destruction of Life, but on the Cultivation of it

That is the remarkable manner in which he has triumphed. It is not wholly unique, for among the ants we know of species which maintain other forms of life, as slaves, or as a kind of "cow" yielding a sort of "milk." Apart from this case afforded by a wonderful insect, there is no parallel to the fashion in which man, seeking to maintain his species against all others, has cultivated and maintained the life of other species to that end.

Students of the history of civilisation require to define its earliest stages, or preliminaries, in terms of the forms of life which man was learning not to destroy but to produce. They recognise a pastoral stage, when man throve by the use of flocks and herds; and we see that his success depended upon the intelligence and patience he was able to employ for the domestication of the animals upon which he depended. The ethical and vital advance, from the hunter to the shepherd, is immense and almost incalculable. Primitive man hunted his prey exactly as the lion, or the shark, or the spider does. It was a revolutionary step forward when man—or, as some writers have supposed, woman—learnt how to tame and breed the animals upon which he depended, so that, instead of merely taking life, he conferred it, and then used it. The case of the Eskimo and the reindeer is as perfect an illustration of dependence on a preserved animal as may be needed.

Man's first culture of life for the life of his own species was doubtless concerned with certain animals. But students of human beginnings recognise an immensely important step when man the hunter, later man the herdsman, became man the planter. Agriculture comes upon the scene. Observing the ways of Nature, man decides to supplement her efforts, and to sow, upon his own account, the kind of seed which he knows will yield him food in its season. Long ago Darwin pointed out that we have no instance of one species existing or struggling for another. The members of a given species will very often live or die for each other, but each species for itself is Nature's way. Here, as in so many other cases, man transcends, as it were, the natural order. Incomparable as a destroyer, he becomes unprecedented as a maintainer and even creator of life. Over vast areas of his planet he decrees that certain forms of grass, called cereals, shall be the dominant form of life. He prepares the ground, he destroys other vegetable forms which he calls weeds, he sows the seed, and he covers thousands of square miles with these grasses, upon which he proposes to browse in a few months to come.

Man's Need to Prepare the Way for More Life of His Own Species

The fundamental character of this relation—Man and Grass—was largely forgotten in the nineteenth century, with its triumphs in the realm of machinery. But hunger remains, and the law of the conservation of energy, which declares that if man is to use his body mechanically it must be fed with fuel. The twentieth century, with its unheard-of aggregations of population—has the reader any idea of the population of these islands only a century ago?—must return, and is indeed returning, to some comprehension of the elementary truth that man, as a living species, is not independent of the rest of life, and that, if he wishes to maintain himself in the world, not the destruction but the creation of life is his only means to that end.

The twentieth century will witness, as never in history before, the intelligent and provident employment of man's powers, both of destruction and of creation, so that the balance of the living world shall be readjusted in his favour. Already, in its first decade, the century has placed on record an extraordinary achievement in destruction—the abolition, in large measure, of certain mosquitoes which are inimical to the life of man. That process will be carried, of necessity, much further. Many parasite-conveying insects must be abolished. The domestic fly must go. The tubercle bacillus must go the way of the leprosy bacillus, and the unknown living cause of typhus fever. But we are to observe that, with all this destruction of dangerous and parasitic life, there must go a construction of the life upon which, to tell the truth, we ourselves are all but parasitic.

Every disease that is controlled or abolished, such as malaria or yellow fever, means that an immense increase of population suddenly occurs, involving a similar increase of the demand upon the food resources of the globe; and those food resources involve man's creation of life of one kind, for his own preservation, while he destroys life of another kind.

The Danger of Man Being a Too Jealous Tenant of the Earth

We have already admitted, for the sake of accuracy and logic, that man might conceivably learn how to construct what he wants from inorganic materials by the aid of the energy of sunlight. Meanwhile, and for ages to come, if not for ever, man must find that the living laboratories which he has employed for so long are vastly superior to and more resourceful and more economical than any which he can contrive. Further, the existence of other forms of life adds to the value of man's life in a host of ways, because of their beauty, and their companionship, and their inherent interest. Man really cannot afford to be too jealous a tenant of his globe. But undoubtedly he will continue, throughout the ages to come, the process of control over other forms of life which he began when first he tried to tame useful animals; and nowadays and for the future he has resources of power which are already almost staggering to contemplate.

Will Man Pass on from Success in Perpetuation to Success in Creation?

We have called some of his actions by the name of "creation," when "perpetuation" would have been a more accurate term. Certain forms of life, already existing, have been useful or pleasing to him, and he has favoured, perpetuated, and multiplied them, just as he has disfavoured and destroyed other forms. But the recent discovery of some of the laws of heredity has endowed man with new powers. These are so remarkably analogous to those already obtained by chemistry that we cannot omit to notice the resemblance.

Chemistry made such advances in the nineteenth century, thanks to analysis, or

FEEDING CITIES HALF A WORLD APART

A PILE OF BAGS OF WHEAT BESIDE AN AUSTRALIAN RAILWAY LINE

LOADING BAGS OF WHEAT AT MELBOURNE FOR SHIPMENT TO INDUSTRIAL ENGLAND

the breaking down of compounds into their elements, that a new chemistry arose which we call synthetic, or "putting together." Until analysis has been achieved, synthesis must obviously be impossible. The chemist today is in large measure a creator. Not merely does he succeed in constructing, by his processes, compounds hitherto made by other forms of life alone: in the chemical laboratories of the world there now exist—and beside many a sick-bed and on many a toilet-table—chemical compounds which have never existed before. The atoms compounding them have existed for untold ages, but they have never been combined in such ways. Man has conceived these compounds, and has called them into existence for the first time, to his very great and increasing advantage.

An Example of How Man May Call New Beings Into Existence

But in the twentieth century man is proceeding to do, for living forms and combinations, what he learnt in the nineteenth century to do for molecules. Mendelism has begun to teach us the laws of combinations, in the structure of organisms, just as Dalton and his successors taught us the laws of chemical combination. And already there exist forms of life in the world which never existed before, and which man has deliberately called into being. Man, the destroyer and preserver, becomes man the creator as well.

If he desires to be able to say so much of any species, he must call it into being himself by his own creative intelligence, and that is precisely what he is now proceeding to do.

An illustration is furnished by the following paragraph from the "Times." "A strain of bees harmless to handle has been successfully hived by Mr. Burrows, of Loughton, Essex. The bees, which have been obtained by mating a Cyprian drone with an Italian queen, are very active workers, and Mr. Burrows claims that they are less liable to disease than the ordinary English bees. The new bees are not stingless, but the sting is innocuous. One hive this year yielded over 200 pounds of honey."

The Right of Man to Destroy Degenerate Forms of Life

The prospect of the future thus begins to open out before us. Man will assume conscious and responsible control over all forms of earthly life, animal and vegetable. He will not permit himself to act in the interests of the present alone; above all in directions where his action is irrevocable. No form of life must be permitted to become extinct through sheer carelessness and neglect; and the higher the form of life, the more stringent must be the application of this rule. The earliest and most essential stages of man's control of all earthly life must undoubtedly be destructive. He must exterminate, either by direct attack or indirectly in various ways, every form of life that is parasitic upon him. He must further exterminate many forms of life, innocuous to himself, which are parasitic upon creatures precious to him—such creatures as wheat, the horse, the sheep. This destructive process need not be regarded as impious, nor as depriving the earth of ancient and respectable forms of life. The parasites peculiar to man are of recent origin, more recent, necessarily, than his own, and they must all be regarded as degenerate. He has brought them unwittingly into existence, by furnishing them with the particular kind of pabulum—his own tissues—upon which they can thrive, and also by such conditions as those of cities, which breed in dirt and darkness such microbes as the tubercle bacillus. What man has thus made, man is surely entitled to destroy for his own advantage.

The Increasing Knowledge of How Vegetable Life Grows From the Soil

The same is largely or wholly true as regards man's domestic animals, and the various plants, such as the vine, which he has, so to say, domesticated. He has established artificial conditions, of overcrowding, confinement, etc., for such creatures, as for himself, and has thus indirectly called into existence the many parasites which can thrive upon them in these conditions. Again, what man has thus called into existence he is surely entitled to destroy.

Man's always unique and astonishing practice of increasing in numbers will necessarily become all the more conspicuous as he learns thus to control and abolish the principal causes of the death-rate among his species. The problem of food supply will thus become ever more urgent, as the number of candidate-mouths increases. We have discarded much of what Malthus taught, but we can still learn from him. The preservation of certain forms of life, and of the edible grasses above all, follows as the basic necessity of man's existence in anything like his present—and much more his future—numbers. This seems simple enough in such a case as that of wheat, but our modern

study of the soil has begun to teach us that the pyramid or ladder of life upon which the human species stands is by no means so simple as we used to suppose. Bread is the staff of man's life, but the life of the wheat-plant requires many living staves of its own. The soil is a theatre of the most extraordinary and complicated vital activities. Already, in Paris, Professor Metchnikoff and his pupils are engaged in the culture of microbes for the prolongation and protection of the life of man; but no less important is the cultivation of the various microbes which exist in the soil, and are necessary for the life of wheat, and thence of man.

How Man Will Become a Breeder, as well as a Destroyer, of Bacilli

Something has already been done in this direction by Professor Bottomley and others. Man will find himself compelled to breed certain bacilli no less earnestly than he destroys others; and the most recent aspect of bacteriology, as exemplified in the work of Metchnikoff, consists in the attempt to produce certain new kinds of bacilli, with new characteristics which may be in one way or another useful to man.

Thus the living population of the globe, animal and vegetable, visible and invisible, is being daily changed by man's activities as destroyer, preserver, and creator of the living world. So far as vegetable life is concerned, the most important work in this direction now being done has its arena in the United States of America. There Mr. Luther Burbank is producing new forms of fruit and vegetables, useful and pleasing to man. There also, in large tracts of Arizona and elsewhere, such distinguished botanists as Mr. D. T. Macdougal are working upon the problem of specific changes, transmissible according to the Mendelian law, and produced by modifications of parental environment and nurture.

Man's Coming Wonders—His Constructions in the World of Life

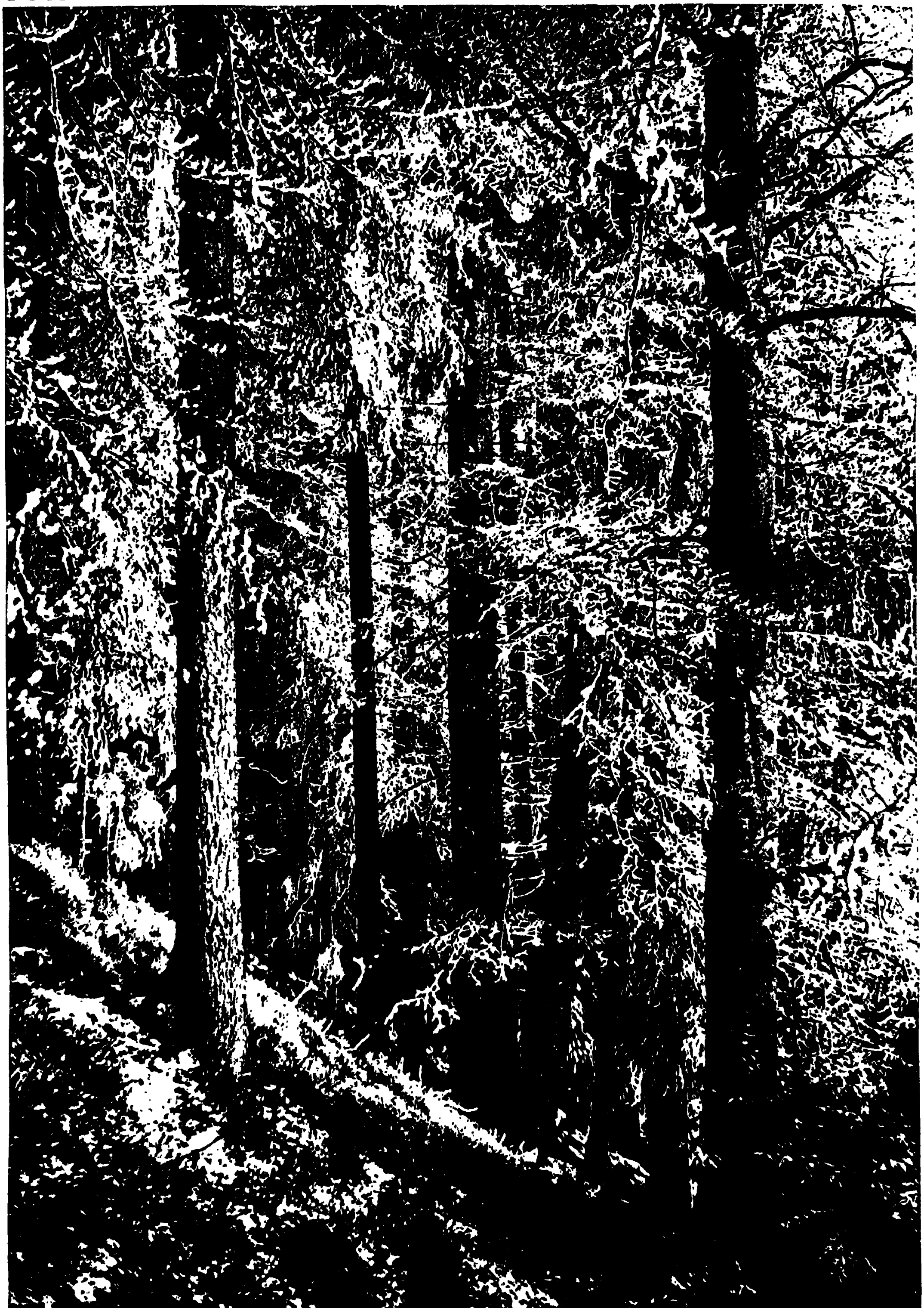
In our own country these problems have proved so enthralling that they have taken Professor Bateson away from his Chair at Cambridge, and he now devotes almost all his time to the actual construction of new plant-organisms in the John Innes Horticultural Institution at Merton, Surrey. What may we not expect when men of his type—leaders in the world's scientific thought—are devoting themselves to practical experiments with a direct bearing on the food supply of future generations?

We are only at the very beginning of things; and if we attempt to limit what shall be possible we shall surely be stultified by the event, as similar prophets have been in the past. But it is certain that all the material constructions of man, his bridges and railways, and houses and canals and dams, will pass into insignificance when compared with his coming achievements of construction in the world of life. The laws which obtain in the realms of physics and chemistry can be applied in the living world; and as the mind in life has used them ever since life began, so the mind in the form of life called man can use them now. Other forms of life have always contented themselves with achieving adaptation to the environment, not-living and living. Man transcends that achievement by first adapting himself to the environment, and then, his position being secure, modifying and reconstructing the environment to suit himself. Hitherto the most notable of his achievements have been in the not-living world, but we have already seen that the living neighbours of any living species are really the most important and influential part of its environment—as food or consumer, or anything between those extremes. Man is now proceeding to reconstruct the living environment and entourage by which he is surrounded.

Man's Journey to the Unknown with Companion Forms of Life

No one can say what the results will be, but we can readily form a picture of a planet inhabited by man, and by a multitude of living species, animal and vegetable, new and old, which fill the earth with use and beauty for man, their master, director, and, in many instances, their creator. This highest form of life is now engaged in grasping the scheme of things entire, and remodelling it nearer to his heart's desire. The directive powers of his intelligence cannot be limited. Thanks to it, his world is already a vastly different one from that in which his species was born, and it is being changed every day, less in the physical details of its surface than in the identity and numbers of the rest of the living world, who, like the dog in M. Maeterlinck's profound play "The Blue Bird," are to accompany and serve the children of men in their journey towards the unknown. In all these things we see, not the impending disasters wherewith faint-hearts so often seek to enshroud the final destiny of the children of men, but signs of an ever-brightening future.

THE SERRIED RANKS OF AN ALPINE "WALD"



A SCENE IN A PINE-FOREST NEAR ST. BEATENBERG, ABOVE LAKE THUN, SWITZERLAND
This photograph is by Donald McLeish; those on pages 4169 and 4173 by Messrs. Hinkins & Son.

THE TREES OF THE FOREST

The Story of the Coming of the Trees: Their Age, Strength, and Adaptability

HOW THEY RESIST THE WINTRY STORM

Despite the incalculable value of forests to a country like Great Britain, until recent years the principles of sylviculture were much more thoroughly appreciated upon the Continent, and especially in Germany, than in our own land. Perhaps the first really scientific work dealing with this all-important subject was that from the pen of Professor Gayer, of Munich, published in 1880. It has ever since been regarded as the most authoritative exposition of sylviculture.

Up to that time there had been a great lack of really scientific study of this subject. Men had been content to cut down forests, and let them grow, without serious attention to explanations of the how and the why in connection with the production of trees. Hence it is not remarkable that very divergent opinions were held by different growers of trees as to what constituted the most accurate and best methods of procedure in certain very important directions. Consequently different procedures were adopted, some in direct opposition to others. All could not be right. One proceeding must be better than another.

Take, for example, the question of whether it is better to grow a forest containing many varieties of trees all mixed together, or whether it is more practically economical and profitable to cultivate what is termed a *pure* forest—that is to say, one consisting of a single species of tree only. Some owners of woodland districts in this country, who might have been supposed to have approached such a question from a scientific point of view, since their own financial profit or loss depended on it, maintained that mixed planting, which was so largely the practice in Great Britain, was detrimental to profitable management, contending that the pure forest was more easily worked and the timber produced from it more readily marketed.

Professor Gayer, however, in his great work already mentioned, and elsewhere, has contended that the above view is completely erroneous. He draws attention to the fact that for the last thirty or forty years of the nineteenth century the Bavarian State Forest Department has recommended the extension and the maintaining of mixed forests in all districts suitable for their growth. Where other methods have been adopted, and the admixture of species dropped, he points out the difficulty of once more establishing the mixed forest. This proved such a real drawback in the long run that great care was taken to retain the mixed character of all remaining forests, and to endeavour to restore that condition as far as possible in localities where it had been dropped.

Among the advantages of producing a forest of mixed woods may be mentioned the fact that denser growth is obtained; that timber is produced which is greater in quantity and of a finer technical quality. The mixed forest runs far less risk from storm and tempest than does the pure forest; it is also less liable to fire. In addition to all these advantages, the destructive fungoid diseases, which do so much to cause deterioration of timber, are less troublesome in the mixed forest than in the pure. The only argument of any importance which can be brought against all these solid advantages is that the mixed forest is more difficult to look after profitably, chiefly because it requires greater knowledge of the principles of forestry in order to make it a success. That, however, is really an argument for the scientific study of sylviculture, rather than an argument against the advantages of the mixed forest. In support of this

view, it may be stated that almost 70 per cent. of the forest areas of France are of the mixed character.

Comparing our British methods of forestry with those recommended by the scientific schools of the Continent, one cannot help being struck with the somewhat thin or sparse growth of our own forests compared with that which the soil might be calculated to produce; and, moreover, a study of British forests would suggest also that their owners have not realised the importance of "under-planting." Under-planting greatly improves the capacity of the soil for production by affording it protection, especially where trees are high; and although our forest land is perhaps more damp on the whole than that of the Continent, and therefore less liable to deterioration, nevertheless where there are grown large numbers of trees like the oak, the larch, the ash, and others, which demand much light, there is no doubt that judicious under-planting will give good returns in the improvement as well as in the output of the timber.

CANDLE-SNUFF FUNGUS GROWING ON A LOG

The scientific name of this fungus is Spheria hypoxylon. A fungus, Polystictus versicolor, growing on a dead beech-bough, is illustrated on page 3204.

Fortunately, in recent years vastly more attention has been paid to sylviculture in this country than formerly; and it looks as if it were probable that in the years to come we shall be as scientific in our methods as the pioneers in this subject abroad. Already there are many lectureships on sylviculture and forestry in our various educational institutions, and in all probability a University Chair on the subject will ere long be established in Scotland. The more widely the knowledge of sylviculture is spread, the sooner will it be realised that there are many thousands of acres of land in this country lying absolutely idle which could be utilised to great profit by their owners, who, apparently, have never thought of afforestation.

Take, for example, the immense number of acres of land enclosed between the fences that separate pasture land from railway lines. One can see no valid objection to planting the whole length of hundreds of miles of such land with trees which in comparatively few years would make a very material difference in the dividends of the railway companies.

It would, of course, be ridiculous to use such areas for growing oaks, or trees of that sort, but why should they not be given over to the cultivation of filberts and other fruit-trees, or be planted with ordinary coppice growth? This would, at any rate, be as remunerative as the gorse and rank mass of weeds which at present usually adorn mile after mile of the grassland by the railway line. This method of utilisation of waste land may be seen in operation in some Continental districts; and that the proximity of the railway does not interfere with the growth of the trees may be seen in many an isolated quarter of a mile or so in our own country where the line passes through woods of long growth.

Moreover, it should be thoroughly recognised that it is becoming an open question whether it would not pay better to use certain agricultural soils and lands in our country for purposes of forest growth than for ordinary agriculture. There are places in which the rentals for the latter kind of use have become so small that they can hardly be called profitable to the owner; and when one looks at the returns of the import timber trade, and observes the immense sum of money paid for Continental and other timber, the question comes home to us whether we could not produce this and keep the profit for ourselves.

We may now take a brief glance at the principal trees constituting the British forests. According to Mr. John Nisbet, of the Indian Forest Service, the chronology of the principal of our forest trees is some-

what as follows. The oak, the beech, the Scots pine, the birch, the ash, the mountain ash, the Scots elm, the sallow, the aspen, the alder, the yew, and the hawthorn were indigenous to Great Britain in prehistoric times. The first introduction of any number of species that we know of with certainty was that by the Romans, who brought hither the chestnut, the walnut, the plane, the lime, the English elm, the alder, the poplar, the box, and many ornamental shrubs and fruit-trees that have never become real inhabitants of the forest. Between the Roman Conquest and the end of the fifteenth century the sycamore, the willow, the hornbeam, and other poplars were introduced. During the sixteenth century we have the addition of the spruce, the laburnum, the holly, the juniper, the holm oak, the alderberry, the viburnum, the mulberry, and other walnuts. To these were added, during the seventeeth century, the silver fir, the maple, the horse-chestnut, the larch (England), and the buckthorn. In the eighteenth century came the pitch pine, the larch (Scotland), the cedar, and one or two others, while only as lately as the nineteenth century had we the eucalyptus, the deodar, Austrian and other pines, and several varieties of firs.

For very many years, in the early history of our own land, both in England and Scotland, the laws relating to forests were of the most stringent character, being directed towards the protection of game. These forest laws contained many harsh and oppressive measures, some of which were repealed in Magna Charta, and others at a much later period. The various wars that from time to time devastated our land were responsible for much forest destruction, especially those of the time of Edward I., when the Duke of Lancaster is supposed to have employed 20,000 men in destroying forests that might give cover to the enemy. Destruction continued in Cromwell's time, both in England and Ireland. Had it not been for our immense prehistoric forest supply in the shape of coal, this destruction would have had even more serious consequences than it had. Our insular climate, with which is associated its comparative dampness, also saved some of the serious consequences.

We can hardly realise the disastrous results of the destruction of forests upon the climate in countries like Greece, Syria, Asia Minor, and parts of Russia. Fortunately, our Colonial Empire provides by far the largest timber-producing area in the world, as well as the most valuable. Still, despite the wonderfully high standard of arboriculture—that is, the culture of trees in parks and gardens, etc.—we yet remain woefully behind other countries in sylviculture. That is very largely due, undoubtedly, to the apathy of our Government in times past.

A FALLEN OAK-TREE, SHOWING ITS SHALLOW ROOT-HOLD

The species of trees which can be grown in pure forests in the climates of Northern Europe are the following. The common pine or Scots fir, the spruce fir, the silver fir, and the larch—all of which are coniferous trees; and, added to these, the hard-wooded beech and oak, and the soft-wooded birch and alder, all four belonging to the broad-leafed type.

The other species commonly found in Great Britain, mixed with various trees, are nine or ten species of pines, the ash, the maple, the sycamore, the elm, the hornbeam, the chestnut, the mountain ash, the white alder, the lime, the horse-chestnut, the aspen, poplars, and the willow.

It must not be supposed, of course, that all these trees are equally capable of being grown profitably in all situations, nor do they all equally improve the soil. (We have already discussed in a previous section how soil is improved by the formation of *humus*, or vegetable mould, and the retention of moisture by trees.) Thus, the beech, with its prolific fall of leaves rich in potash,

produces excellent humus, whereas the oak, the ash, and the elm, and other trees which are very valuable from the point of view of timber, take perhaps more out of the soil than they return to it. The spruce and the silver fir, and some pines, act beneficially, but the Scots pine and the larch have insufficient foliage to enrich the soil.

Nowhere is the principle of natural selection and the survival of the fittest more strikingly demonstrated than in the production of forests where the hand of man has been absent. In Scotland, Nature selected the Scots pine to predominate on the mountains; while on the more fertile soils of southern Scotland and the north of England, oaks, ashes, willows, alders, and yews grow well. Coming further south, especially on the more chalky lands, there were found great areas where the beech and the oak flourish magnificently. Similarly, in Scandinavia the pine forests predominated. And so in the different Continental areas one or other species of forest tree was selected by Nature as the most eminently suitable for that locality.

A WOODLAND SCENE SHOWING BIRCH AND BRACKEN

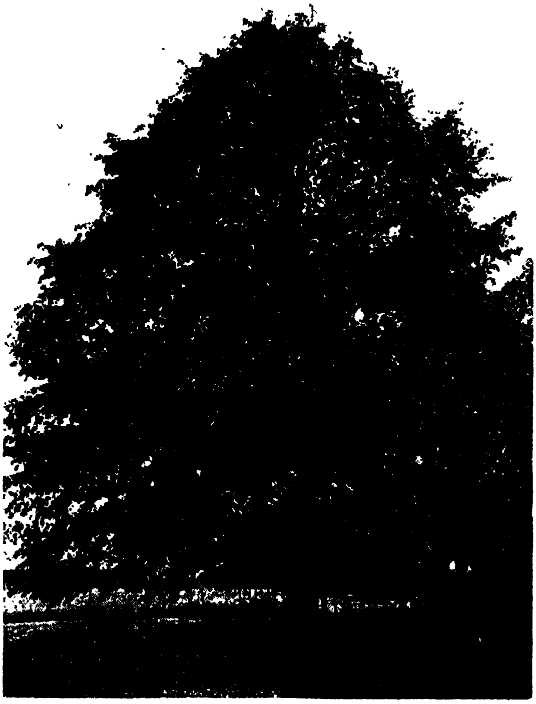
In our last chapter we discussed various questions relating to the growth of forests in reference to different soils, and also dealt with the various methods of raising timber crops in general, noting also some particulars of differences found in forests according to the condition of the climatic influences of warmth, light, and moisture.

Although we are well aware that these factors play an important part in the growth of trees, very little is known concerning the amount of light and warmth required for different species.

A rough grouping of trees in this connection (such as that given by Gayer) indicates that the larch, birch, Scots pine, aspen, willow, oak, ash, chestnut, and mountain pine demand a large amount of light. Trees which occupy a somewhat intermediate position in this matter are the elm, alder, Austrian pine, lime, maple, and sycamore. A few trees flourish even in the shade, such as the spruce, the beech, and the silver fir.

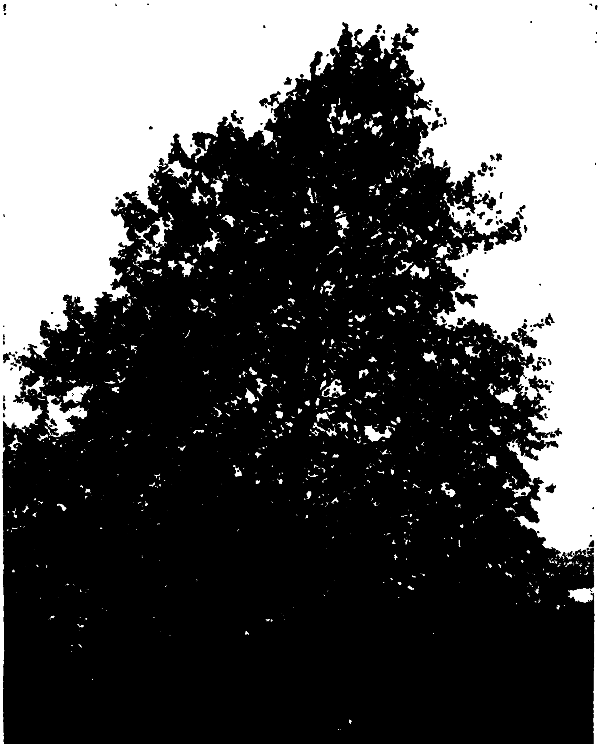
In the same way there are remarkable differences among trees in their liability to injury from frost, the most delicate in this respect being the ash, acacia, chestnut, and the beech. The intermediate species include the oak, silver fir, maple, sycamore, spruce, and alder; while the lime, elms, birch, larch, Austrian and Scots pines may be described as hardy in this respect.

Depth of soil, too, is an important matter in regard to forest growth, because, of course, the root systems of different species of trees vary very much. It may be stated in general terms that most forest trees require a soil varying from one to three feet in depth, while none demand greater depth than five or six feet, this being sufficient even for the oak. Roughly speaking, we may say that the spruce, the aspen, the mountain ash, the birch, and the mountain pine will flourish in a soil not more than one foot in depth, their root system being superficial. The beech, the alder, and Austrian pines do better in soil a little deeper. The Scots pine, silver fir, maple,



THE LIME

THE HORSE-CHESTNUT



THE PLANE

THE LOMBARDY POPLAR

sycamore, ash, lime, and chestnut should have a soil of from two to three feet in depth, while the oak and the larch only succeed to perfection in three or four feet of soil at least.

The amount of moisture required by different trees would form another grouping. The alder, the ash, the willow, the maple, and the elm require a large quantity. The oak, birch, aspen, and larch flourish in considerable moisture. The beech, the lime, and silver fir need a moderate amount, while pines of different species can flourish where moisture is least. Put in another way, it will be observed the broad-leafed trees demand more moisture from the soil than do the coniferous species.

The Rapid Growth of Trees to Their Maturity

With regard to the demands made upon the nutritive elements contained in the soil, it would seem that the elm, the maple, the sycamore, and ash head the list, these being followed by the oak, beech, lime, silver fir, aspen, and willow. Then come the larch, birch, alder, and spruce, while the pines are of the least exacting character.

It frequently becomes a matter of great importance to know the length of time at which any given species of tree will require to attain its maximum growth or its average growth. Among those which grow most rapidly are the birch, larch, alder, maple, sycamore, ash, elm, willow, and Scots pine. Fairly rapid growers include the oak, the beech, and other pines, while among the slowest are found the spruce and the silver fir. Considerations of soil must, of course, be taken into account.

The Length of Life of Different Kinds of Trees

Forest trees produce their maximum quantity of seeds at the end of the period of their most active growth in height, and then the crown of the tree begins to develop. From thence seed-bearing goes on until near the end of the life of the tree, but the seed produced at the two extremes of life is inferior in quality to that of the middle period. On a previous page we mentioned some remarkable figures in connection with the age of certain individual species; and it will be interesting here to add the ordinary limits of the average of common forest trees, according to Gayer. The aspen, birch, alder, willow, and poplar seldom attain more than a hundred years. The ash, maple, sycamore, spruce, larch, and Scots pine may attain about two hundred years. The English elm, the beech, and the silver fir live from three to four hundred years; the chestnut, Scots elm, the lime, yew, and the oak attain five hundred years and upwards. Of course, there are many trees in England and other countries whose age-limit far exceeds some of the figures above given, but those are cases of individuals, not of average forests.

The strength and resisting power of wood are its principal virtues, and give a tree its greatest commercial value as a rule. The strength of the tree is a necessity of its existence. Without it, it could not rear its immense bulk, nor keep it erect in the presence of wind and storm. The strength must be placed in the stem or trunk to sustain the weight of foliage and flowers which have to be held up into the air and light in order that the great growth inherent in the species may be fully attained. We have already seen that this same stem or trunk carries within it all the channels of food conduction, which must be preserved and protected. In some way or another they must be saved from the possible injurious effects of strain and bending of bough and stem.

The Natural Devices by Which Trees Resist Strain by the Wind

So universally recognised is this great strength of trees that we regard it as a test of the violence of storms when trees of large calibre are blown down or dispossessed of their branches. How, then, do they attain such powers of resistance? How is it possible for the giant oak to brave the storms of a thousand years? The phenomenon is well worth more than a cursory glance, and we may attempt some explanation of it here.

The phenomenon is the more striking if we bear in mind the enormous weight of the individual parts of a large tree in comparison with its somewhat slender trunk, the number and extent of lateral branches projecting for great distances, it may be, from the main central trunk, and bearing upon them the great burden of many thousands of thick leaves. Obviously the greatest strain must fall ultimately upon the lower portion of the trunk.

The direction of the pressure will fall in the direction of this main axis, and there obviously must be some arrangements that confer upon it columnar strength. Not only so, but it is also obvious that this strain will not, as a rule, be acting exactly in the central line of the axis, because trees, with few exceptions, are not exactly bi-symmetrical. One side or the other will

have to bear greater strain, according to greater development and growth. That means there will be a tendency to bending, and this must be guarded against. If one thinks how a strong wind must change the position of the centre of gravity in a great tree, the necessity for strengthening structures is made even more patent. It is, indeed, astonishing to what a degree bending of even great boughs is possible without involving a break in the main stem.

Why should a branch not break off when it bends to the wind, instead of resuming its normal position? The answer building. "We are reminded" (says Kerner) "of the system of tubular bridges, in other cases of that of lattice bridges; here of a massive, pillar-like structure with architrave and flattened top, there of a Gothic building with pointed arches, buttresses, and steep gables, but the special conditions of the habitat are always taken into consideration, and the whole structure, for this reason, always exhibits the greatest adaptability of the means to the end."

The builder uses different pieces of material in his construction, and Nature

A MONSTER BEECH IN ITS PRIME AT MARKASH, IN THE NEW FOREST

gives us the secret of the strength of trees.

The same problem confronts the engineer when he has to construct a bridge over a river, or fix a support for some high edifice. He has to find some mechanical arrangement of his material which will give him the maximum of resistance with the minimum of outlay, and this is exactly what Nature does in the construction of a tree. Moreover, her systems of structure are wonderfully analogous to those used by man in produces in the tree special mechanical cells. Mechanical cells are those whose function is passive, rather than physiologically active. Their value is in their strength, not in their peculiar properties of secretion or some other complicated function. They are like the bone-cells of our skeleton, which are mechanical in function as compared with the extraordinary physiological function of brain-cells. So in the plant we have these protective cells

surrounding and protecting the more delicate ones, which otherwise might perish.

The material thus used in a tree is termed the *hard bast*. It consists of cells of a thread-like or spindle-like shape. The ends of these spindles are dovetailed into each other, producing an arrangement which confers immense resisting power. The cells themselves have thick, strong walls and but a small cavity: the latter, indeed, may be a mere slit. To aid the whole, a spiral arrangement is added, on the same principle as threads are twisted into string. When these cells are once full grown, they have no other function than the passive one of bricks in a framework. They are a mere piece of architecture. The strength of this bast tissue is almost incredible, until we think of the bough bending in the storm. It is often equal to that of wrought iron, and in some species has a bearing capacity equal to steel. But it is better than iron for this purpose because, in addition to its immense strength, it is extremely elastic, for without that property it would fail in its purpose. This makes it so hard to break.

In addition to these hard bast cells, we have two other cells for the same purpose, namely, *woody fibres*, or *libriform cells*, and a special tissue termed *collenchyma*. The woody fibres are an essential part of the stems of plants and trees that add to their size by laying down *annual rings*, the production of which we have already referred to as the means of increasing the circumference of the trunk. They are made of cells a little shorter than those of hard bast, but, like them, have walls of very firm, dense texture adapted for strength and mechanical support. The hard bast does the work of support and protection until the bark is produced outside, and, after that, the woody fibres supersede the cells in this task.

Like the hard bast and the woody fibres, the *collenchyma* is made of long cells with strong walls, but their special feature is that their walls are not of equal thickness. Moreover, they have more cellular protoplasm within. This gives them a greater capacity for growth. Hence *collenchyma* has advantages over both hard bast and woody fibres—in fact, it is a necessity where the stem is still growing. It keeps pace in growth with the other parts of the stem, just as the builder keeps adding scaffolding as his edifice rises. The strength of *collenchyma* is, however, not so great as that of the other mechanical cells; it could not be. None is more important than another; each is wanted at different stages and in different situations. All three comprise the *mechanical tissue* of a plant.

Mechanical tissue, to be of greatest service, is arranged in strands parallel to the long axis of the stem, as this gives the greatest effect. If they were in the centre of the stem they would be of but little use in the resistance required against bending, because, when bent, the shorter side of the stem is compressed, and the lengthened side extended. The strengthening material must be available where the force of bending is greatest, and this may be anywhere at the periphery of the stem, since bending may occur in any direction. The builder recognises this when he applies a flange to either *side* of a beam when he wishes to strengthen that beam. He makes what he calls a *girder* in that way. The material between the flanges may be very delicate, but the result of the mechanism gives considerable strength. Just such an arrangement is seen in leaves, but it is insufficient for the resistance required for stems and trunks. They must be supported, as we have said, in every direction, and against pressure from all sides; and so, to meet this demand, Nature provides all sorts of combinations of mechanical girders, each serviceable in its own way.

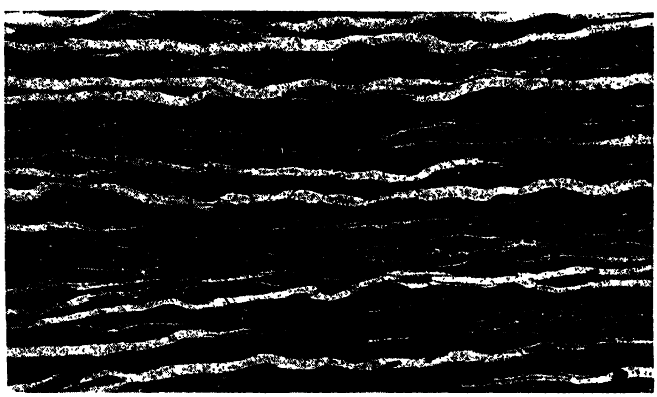
LONGITUDINAL SECTION OF THE MATURE WOOD OF AN APPLE-TREE

This mechanical tissue has three main forms of arrangement to resist undue bending and breakage. In the first we find the girders are of a simple character, with flanges of hard bast near the periphery the line connecting them passing through

the axis of the stem. This is the supporting arrangement found in most of the young stems of trees like the oaks, maples, limes, elms, and willows. Remember that, later on, this hard bast is replaced by the woody fibre, or libriform tissue.

The second arrangement exhibits the flanges of a number of simple girders fused together as regards their sides, so as to form a complete tube or cylinder. This, too, is placed towards the periphery for strength-giving purposes. It is made from the hard bast. It is at once obvious how this will offer great resistance to bending, the cylindrical arrangement making for great power in this respect.

In the third arrangement, the flanges are developed as secondary girders, made of hard bast. They may be in the form of a circle, or in several circles one within another. The arrangement in the bamboo is of this latter character. All these three methods are directed towards the same end, and are but one more of the many instances we have studied of the wonders of plant evolution, or adaptive growth and change. In fact, it is abundantly obvious that our whole study of plant life has shown us this one thing above all others—that each and every part of the structure of a plant, from the tiniest moss to the grandest denizen of the forest, is marvellously perfected for some special function, either of an actively growing nature, or—as in the cases we have now been considering—for purposes of mechanical support.



TRANSVERSE SECTION OF THE MATURE WOOD OF AN APPLE-TREE

Forestry has for its object the supplying of the world with wood, and the most formidable competitor of wood is iron, which has in some directions—as, for instance, in the building of battleships—left it far behind. But, in concluding our study of trees and plants, let us for a moment compare these two, and see their relative advantages and disadvantages. We shall in that way, perhaps, better appreciate the place of the forest in the world's economy.

Wood is one of Nature's products. It *grows*. The production of iron involves a costly manufacturing process, and is only possible in certain places. Wood of some kind can be grown almost anywhere, certainly anywhere where men do congregate. The supply of iron is exhaustible, while wood can, and ought to be, grown for ever. Properly managed in its growth—that is, under scientific systems of sylviculture—wood is cheap. Iron, like all metals, is comparatively expensive. Wood is soft enough to be manipulated by simple tools, and, for a similar reason, requires not much strength to be applied to it. Iron is so hard that very costly machinery or much labour is necessary to change its shape as may be desirable. Wood can be split; the structure of iron forbids this. The strength of the two is not so much in favour of iron as might be thought, as we have already mentioned. The strength of wood may even equal steel. The lightness of wood contrasts with the heaviness of iron, wood averaging some thirty-one pounds per cubic foot, iron being from four hundred and thirty pounds. This aids the handling and carrying of wood, and allows of it floating. Wood conducts heat and electricity badly, and so can be handled when iron cannot. Wood burns, however, and iron does not. Yet even here wood has something in its favour, because, when burning, it retains its shape, while iron, when heated, twists and warps more.

Wood is singularly resistant to many chemical changes to which iron is susceptible; hence it can be used to keep fluids in for great lengths of time. Moreover, wood is easily put together, even by adhesive substances. It is an invaluable fuel for the mass of mankind. It furnishes us with paper and furniture, charcoal and vinegar, alcohol and creosote, gas and tar, acids and lampblack, and a host of other materials. And, lastly, in its growth it gives the human race visions of beauty, grace, and strength, which have served poets and humbler folk for inspiration in all ages.

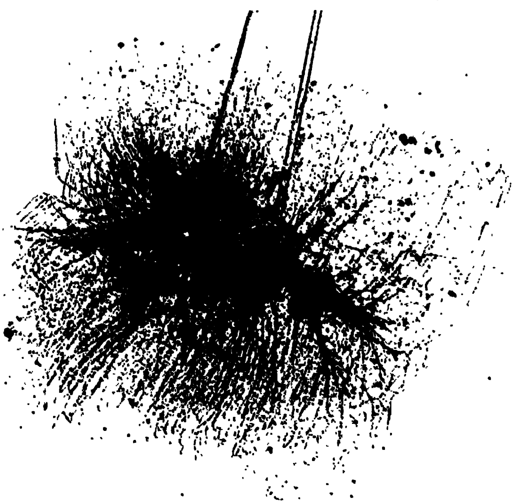
THE MARVELS OF THE SPIDER'S ANATOMY

MOUTH, WITH POISON FANGS

HEAD, SHOWING EIGHT EYES

FOOT, WITH COMB-LIKE CLAWS

A SPINNERET OF THE GARDEN SPIDER, SHOWING TUBES FOR THE DISCHARGE OF WEB LIQUID



ATTACHED ENDS OF A SPIDER'S THREADS

THE SPINNERETS OF A SPIDER

The photographs on these pages are by Messrs. J. J. Ward, Hinkins & Son, S. C. Johnson, G. L. Lyle, and Martin Duncan

FROM WORMS TO INSECTS

The Bridging of the Chasm Between Bristles and Jointed Limbs

STRANGE CHAPTERS IN NATURAL HISTORY

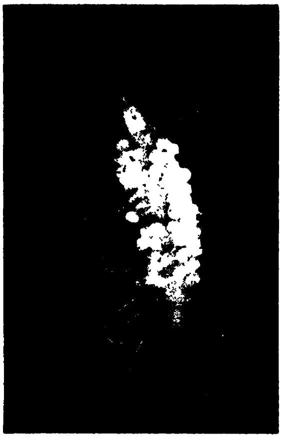
In an earlier chapter, beginning on page 293, we traced some of the evolutionary changes in animal life which the observer may witness in progress, practically before his eyes. The present chapter demands that the mind take a leap across a vast span of life to view latter-day results of similar developments. To do so we must disregard conventional classification; for while one aspect of our chapter faces the large sub-kingdom in which the worms, marine, terrestrial, and parasitic, are brigaded, the other is confronted by the highest type of backboneless animals. From Vermes to Arthropoda is a far leap today; but among the worms are descendants of the forms from which the vast assemblage of Arthropoda took their rise. Our survey suggests a fascinating train of improvement, achieved through long ages, with many a prolonged pause, with many a branching-off of new types, with many a regression and backsliding. We begin with forms which yielded the worm in its burrow, or the loathsome parasite in the flesh of its living host; and at the other end of the scale we have the lobster in her sea-steeped cavern, intelligently sheltering her brood about her; the spider flinging her silken beams across unbridged chasms; the ant and the bee in their marvellous model cities.

This is indeed a prodigious march by unassisted Nature, but we can trace the direction in which that march has been made. The mould of forms, indeed, is broken, but we can still discover likenesses between types of life now almost immeasurably far sundered. Among the worms are extremely primitive as well as degenerate types; among the Arthropoda are the most highly specialised of all invertebrates. The Arthropoda embrace five most interesting classes—the jointed-limbed animals; the Crustacea (crabs, lobsters, barnacles, etc.); the Arachnida (scorpions, spiders, mites, and ticks); the Myriopoda (centipedes and millipedes), and, in the Insecta, all the host of insects.

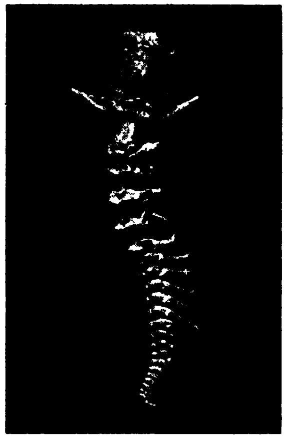
Truly there seems at first sight little to associate the despised and lowly worms with masters of arts and crafts such as we find among the other great sub-kingdom. Many important groups separate them; the Arthropoda, as a fact, constitute the second sub-kingdom of the animal world, while the worms form the seventh. But, far a the Arthropoda have travelled, they still, in important particulars, agree with such humble creatures as the bristle-worms, and certain of their allies. They are all, for example, divided into rings or segments, and their central nervous system consists of a ring round the front part of the digestive tube, thickened into a brain above, and continued behind into a ventral cord, which swells into a varying number of ganglia. Instead, however, of possessing paired, hollow foot-stumps at the sides of the segments, as is the case with certain of the worms, the Arthropoda are provided with pairs of solid-jointed limbs, of which at least one pair is modified into jaws. Cilia, which play an important part in the life of the adult or larval worm, are absent from the Arthropoda.

The briefest glance at the worms must suffice. Their classification is by no means a simple matter, for we have many forms associated whose features in common are rather negative than positive in that they are to be identified, as to some cases, by the absence, rather than the presence, of certain characters by which the remainder may be recognised, whether worms or Arthropods. The Archiannelida, minute and primitive marine worms, are to be noted as suggesting the characters of the ancient stock from

which were derived the Annelids, a group in which, among other forms, we find the earth-worms and leeches. The larvæ of one of the Archiannelida (the Polygordius) assume a remarkable form, known as the trochosphere, which ultimately becomes merely the head of the adult body, which latter develops as a narrow outgrowth at the rear, where it is divided into a number of segments. A similar larval peculiarity is associated with several of the next class, the Chætopoda, or many-bristled worms. These are a numerous assemblage of worms, marine, fresh-water, and terrestrial, agreeing, for the most part, in the possession of bristles projecting from the sides of the segments, where, in many instances, foot-like processes, called parapods, appear, and serve for the purposes of locomotion.



A BRISTLEWORM WITH ITS EGGS ATTACHED



CHÆTOPTERUS, A PHOSPHORESCENT WORM

A well-known example is the sea-centipede (Nereis), a worm which may be seen crawling actively, at low tide, in search of living prey, which it seizes by means of powerful hooked jaws. An allied form, Palolo viridis, is eaten in great numbers, raw or baked, by Samoan, Fijian, and other island natives. The so-called sea-mouse is merely a bristle-worm, and leads us on to the worms that dwell in tubes of their own making. A familiar example is the lugworm (Arenicola piscatorum), which fishermen probably regard as specially designed for use as bait by the sons of Walton. As a fact, it is one of the creators of a clean seashore. The lugworm eats sand for the sake of its organic contents, cleansing it, and rendering it small and fine. Its work is compared to that of the earthworm, for it is computed that in the course of a year the lugworms of an average acre of seashore will produce in castings about 1900 tons, or a layer of thirteen inches.

THE SEA-MOUSE CLOTHED WITH IRIDESCENT HAIRS

Three notable forms of bristle-worms are the Chætopterus, which lines its burrow with a parchment-like substance secreted from its own organs; the Terebella, equipped about the head with tufts of filaments and cilia, which set up currents in the water bearing food to the worm; and the Serpula, which fashions calcareous tubes on rock or stone or the empty shells of molluscs. Our next class, the Oligochæta, or few-bristled worms, are undoubtedly an offshoot of the foregoing group, but they have been vastly more important to the world. Here we find the earthworms, which Darwin, who devoted thirty years of intermittent study to the subject, considered the most important animals in the world in preparing the soil for man. Cowper little dreamed how well justified, on material grounds as humane, was his protest:

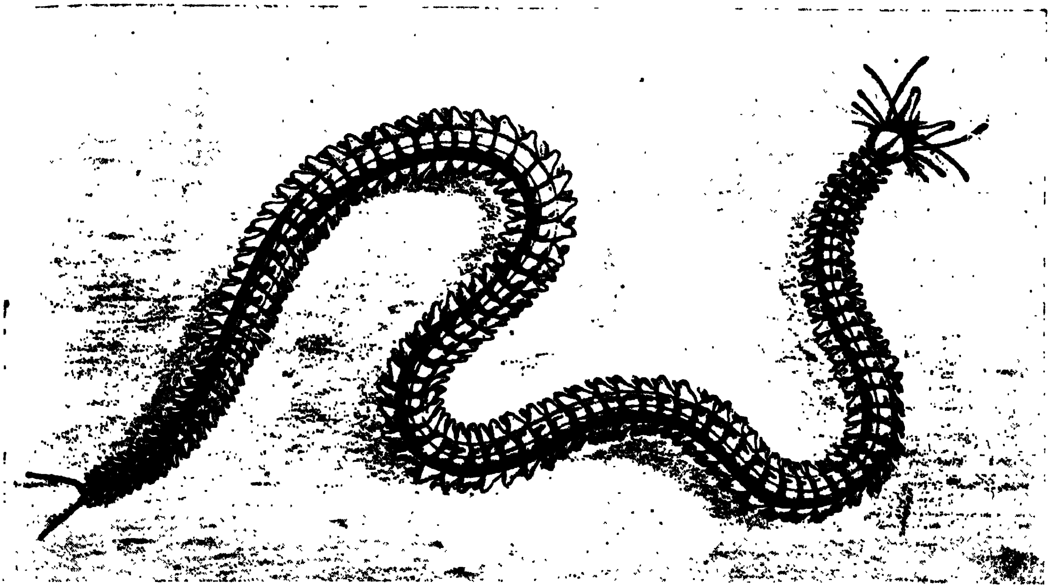
> I would not enter on my list of friends. . . . the man
> Who needlessly sets foot upon a worm.

The worm is both earth-dweller and earth-eater. It tunnels in the soil and eats it for the organic substances contained. It draws into its burrow all manner of vegetable substances; and the leaves which we see standing upright, with their stalks embedded in the ground, upon our lawns—these leaves, tiny bits of twig and straw and hay, and so forth, have all been drawn into that position by the worms. Darwin calculated

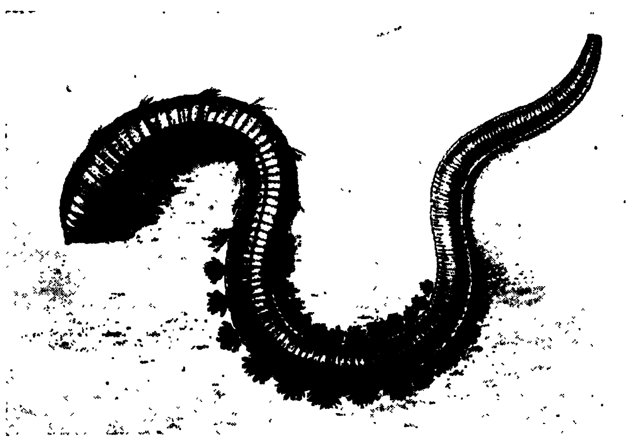
that in an average acre of garden soil there are about 53,000 worms, and that in the course of a year about ten tons of earth pass through their bodies. The result is that, in voiding the soil thus swallowed, they bring up earth from below representing a layer of three inches over the acre in the course of fifteen years.

"Nay, never grumble at the worm-casts," said a well-informed head gardener upon a large estate to his staff. "Take your broom and lightly distribute the casts over the lawn; it is the best soil in the garden, and the great natural lawn-improver." Worms are constantly at work aerating and draining the soil, reducing the loam to a fine state of division, and effecting that mixing which the farmer seeks by plough to do.

Grant-Duff mentions in one of his diaries the interesting fact that certain intelligent African tribes make their homes where they find earthworms plentiful, knowing that agriculture may be successfully practised only where these lowly creatures abound. The natives have a wider choice of these animated ploughs than is possible in temperate England; for in Africa, as in the East Indies, earthworms attain a length of three feet and upwards, with a girth equal to that of a man's finger; while Australia has a related form (Megascolex gippslandicus) which measures six feet in length, and is said to make a "gurgling sound" as it retreats underground. We need not on this account accredit it with vocal organs, however, for the "gurgle" is probably akin to the curious sucking sound made by the withdrawal by a big tortoise of his head into his shell. It is the rapid expulsion of air, not the voice of the tortoise, that we hear.



AN ACTIVE CARNIVOROUS MARINE WORM—NEREIS, THE SEA-CENTIPEDE



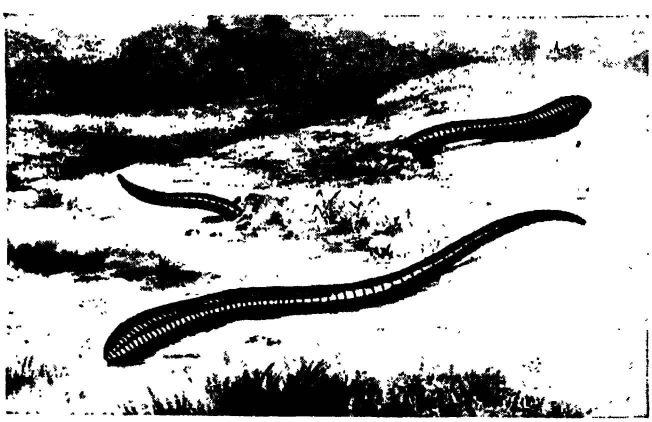
A SEASHORE SCAVENGER—THE LUGWORM

Like other forms of lowly life the earthworm can survive, under favourable conditions, the loss of part of its body. This is not surprising when we remember that a fresh-water member of the family, the

beaked nais (Nais proboscidea), propagates by a process of transverse fission or division. The ordinary earthworms combine both sexes, but for the fertilisation of their eggs they pair. These eggs are deposited in spindle-shaped cases or cocoons, formed by the hardening of a secretion from the parent organism. As mentioned, the earthworms are members of the few-bristled class. The bristles exist along the sides of the segments, and may be distinctly felt if a worm be drawn across the hand. It is these scale-like points which give the worm its purchase upon the ground, enabling it both to crawl and to retain its hold upon the interior of its burrow when an enemy seeks to draw it out.

THE HORSE-LEECH

So far as the present writer has read, it has not been noted that the worm is able to concentrate enormous muscular effort into the resistance of a moment. A worm which you seek to draw from its burrow will oppose the first pull even to breaking point. But if it be held taut for a moment, then pulled a second time, it yields, almost without resistance, to the second tug. All its power of violent resistance seems to be exhausted by that first tremendous effort to withstand abduction. It will still cling, of course, as an entangled branch of briar will, but the retractile energy appears to be dissipated by the initial effort at escape.



THE FIRST PLOUGHS—EARTHWORMS

Following the few-bristled worms come the leeches, of which the medicinal leech (Hirudo medicinalis), once a famous ally of the surgeon, is distinguished by the possession of three saw-edged jaws for piercing the flesh of a victim, and a duct from which is poured a fluid that keeps the blood from coagulating, and so makes a leech wound difficult to stanch. Among a great variety of other animals in this group we have the trichinosis worm; the threadworm (Filaria sanguinis-hominis), which gives rise in man to the disease known as elephantiasis the parasitic round and thread worms which in various stages pass from invertebrate host to vertebrate, not seldom making man their medium. Then we have also the loathsome tapeworms which have, as intermediate hosts pigs, oxen, freshwater fish, dogs and other animals and, finally, man himself.

The life-history of these disgusting parasites teaches one or two lessons: never to eat undercooked meat; never to eat salad unless we can be sure that it has been scrupulously washed; never to permit dogs to stray near vegetables from which salads will be made, and never to permit them to be near water which may be drunk; never to permit a dog, whose tongue may carry the ova of these parasites, to lick our hands or faces, and, further, to keep our domestic pets free of fleas, which are often the first host of the ova of the tapeworm. The history of the parasitic worms is essentially unpleasant, and need not be more definitely traced; it is strange and terrible enough to justify the student's seeking it in its proper technical setting.

And now, having thus glanced at this lowly order of life, back to which we trace the rise of insect and related forms, we may pursue our way to the higher phases of life to which the collateral descendants of the

ancestors of the worms have attained. We advance at a bound to the scorpions, for we have, in preceding chapters, passed in review the most remarkable marine forms of the Arthropoda, and, in our study of the ants and wasps and bees, have taken a preliminary survey of the highest expression so far reached by this great sub-kingdom of Arthropoda.

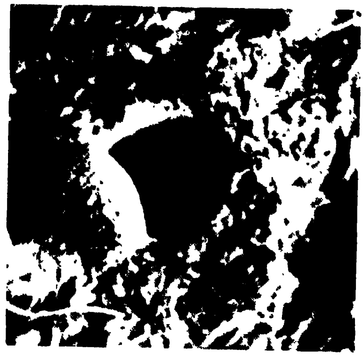
The scorpions, spiders, mites, and ticks together constitute the Arachnida. Conversationally they are insects; scientifically they are not. In insects the head, thorax, and abdomen are clearly departmentalised, so to speak; in the arachnids the head and thorax are intimately united. The insect has six legs; the arachnid has eight. In some of the arachnids—the harvestmen, the mites and ticks—the cephalothorax, *i.e.*, the united head and thorax, is completely fused with the abdomen.

The first of the class are the scorpions, of which the warmer climates possess some ten-score species. Only the smaller kinds are known to Europe, the eight-inch examples being restricted to tropical lands. The large pincer-claws (pedipalps) serve for gripping prey; the small pair of pincers (chelicerae), lying one on each side of the tiny mouth, serve further to grapple the victim nearer the mouth. The long tail contains at its extremity a sharp-pointed sting, which communicates with a poison gland. From this virus is ejected into the wound caused by the sting. Small animals, such as spiders, insects, and lesser vertebrates, constitute the prey of the scorpion. Nourishment is assimilated by suction, so that only the juices of an animal can be taken. Perhaps it is needless at this late day to mention that the legend as to the menaced scorpion's stinging itself to death is false. Just as a snake cannot poison either itself or one of its own species, so the scorpion is immune to the effects of scorpion virus. Great antiquity is attributed to the scorpion, which is believed to have arisen from a marine stock, of which the still existing king-crab is the modern representative.

A LINK WITH THE FAR PAST—THE SCORPION OF CENTRAL AFRICA

The cousins of the scorpion, the spiders, are a numerous and specialised group, with a vast distributional range, and an infinite variety of devices in making a living. Needless to say, they are all carnivorous, and, that being so, they are, with few exceptions, entirely desirable members of the animal family. Apart from the wonders of their webs, spiders reveal amazing skill in some of their domestic plans. The engineering of the trap-door spider's home, for example, is a beautiful example of self-help. Compare that wonderful tiny dwelling with the abode of the cave-man. The entrance to the little home is the finest of all artificial portals not made by hands. Beneath is a neat and well-designed burrow, luxuriously lined with silk, and closed against intrusion by a perfectly

modelled door hinged with silk, and closed with the same material. The builder, not content with making all secure within, conceals the door of its dwelling by embodying in it fragments of moss or leaf or other vegetation, with the result that the whole exactly matches the surroundings. The scheme is deliberate, the resemblance of the trap-door to its environment is not accidental, for an investigator, having carefully excavated so as to carry away the top of the burrow with its door, returned a day or two later, to find a new door built, and its exterior crowned with earth and fragments of moss, which had been carried from a bank above. Some of



THE TRAP-DOOR NEST OF A BIRD-CATCHING SPIDER

closes that door after it, and remains perfectly hidden. We may call that instinct if we like, but it is an instinct utterly eclipsing anything achieved by the highest vertebrates, man alone excepted. Think of the rough nest of broken twigs in a tree at the Zoo made by an escaped orang-utan the other week, and then picture the silken fortress of this little spider, and the contrast makes the work of the spider inestimably admirable.

But there is a still more challenging wonder in the work of the water-spider. This is as completely terrestrial an animal, so far as physical organisation is concerned, as the commonest of house-spiders. Yet this little

A WATER-SPIDER BEARING AN AIR-BUBBLE TO ITS NEST AND CAPTURING ITS PREY

these trap-door spiders are not comfortable with only a single door between themselves and the outer world; they have two—one below the other. Another species improves even on this, by making a second tunnel or tube, which branches off the primary one, half way down, and ascends nearly to the surface, where it ends without exit. This would be useless without design behind it, and there is design. The opening between the two tubes is artfully closed by a trap-door, which is hidden behind the silken lining of the main tunnel. When its home is invaded, the spider pops behind the arras, opens the door, passes through to the other side,

THE EGG COCOON OF A SPIDER HANGING FROM A STALK

animal (Argyroneta aquatica) makes a subaqueous balloon, rears its young within it, and itself passes the winter within its shelter, under water. A beautiful contrivance is this little home of the water-spider, a dome-shaped bag of silk, woven beneath the water, and attached to the stem of some plant, so that it is prevented from rising to the surface. The little balloon is inflated by the spider, which carries down a bubble of air at a time, such bubble clinging to the hairs growing upon its body. And in that little, magic abode this air-breathing animal dwells, when not out hunting, sustained by the oxygen which itself has carried down,

A HOBGOBLIN OF THE SPIDER CLAN

A BIRD-EATING SPIDER OF THE WEST INDIES

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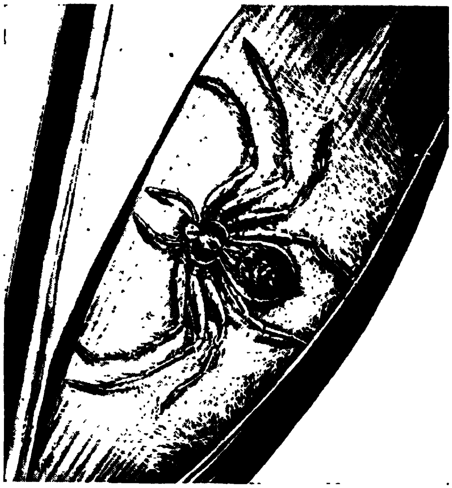
an air-bead each journey. No fairy tale ever suggested a prettier idea. The water-spider anticipated by uncountable ages the human inventor of the diving-bell.

Then there is another water-haunting spider, the raft-spider (Dolomedes fimbriatus), of which we have a well-known family in England, the Pisauridæ. This little genius constructs, and goes a-sailing on, a raft of tiny leaves, joined with infinite skill. From it she leaps every now and then, on to the surface of the waters, to catch an insect, treading the watery way with quite as much confidence as that merry water-treader the pond-skater.

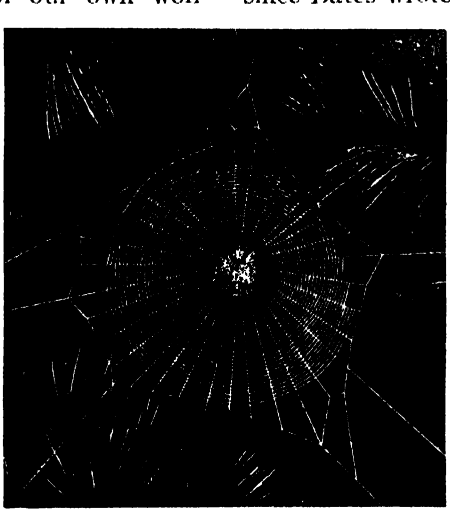


THE SPIDER, PHILODROMUS, IN ITS NEST ON A REED

Even these little beauties have a venomous sting. All spiders have: the tarantula worst of all. This much-maligned spider is simply a larger cousin of our own wolf-spider, and undoubtedly gives one a shrewd nip, which is followed by considerable pain, though not nearly so bad in effect as the sting of a scorpion. The tarantula has a shocking name. In the Middle Ages an epidemic suggesting St. Vitus' Dance spread over South Europe, and, because it was attributed to the bite of this spider, it was named tarantism. There has been a revival of it in Italy within the last few years, and distressing accounts were published not many months ago. The disease really has no more to do with the tarantula than with the dodo, but is simply a nervous affection to which hysterical people are subject. In the old days music was declared to be the only cure, and a dance known as the "tarantella" is said to have originated from this treatment. The legend is probably as authentic as that explanation once given to Queen Victoria as to the origin of the Highland fling—the kilt and midges! Experiment has shown that the bite of the tarantula, though painful, and followed by local irritation, is neither fatal nor succeeded by any serious ill.

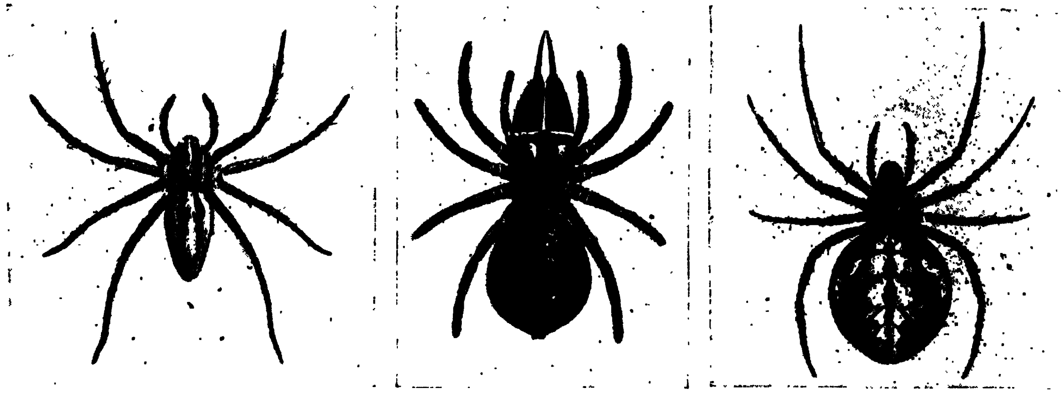
The most loathsome of the spiders are the bird-eating examples (Aviculariidæ or Mygalidæ), happily restricted to tropical or sub-tropical climates. Little has been added to our knowledge of these animals since Bates wrote of them, and his descripoion must still stand. "Many species of these monstrous hairy spiders, half a foot in expanse, which attract the attention so much in museums, are found in sandy places at Nazareth. The different kinds have most diversified habits. Some construct, among the tiles or thatch of houses, dens of closely woven web, which, in texture, very much resemble fine muslin. These are often seen crawling over the walls of apartments. Others build similar nests in trees, and are known to attack birds. . . . At Cameta (Equatorial Brazil) I chanced to verify a fact relating to their habits . .

CONCENTRIC THREAD OF A GARDEN SPIDER SHOWING GLOBULES TO WHICH INSECTS ADHERE



THE WEB OF A GARDEN SPIDER

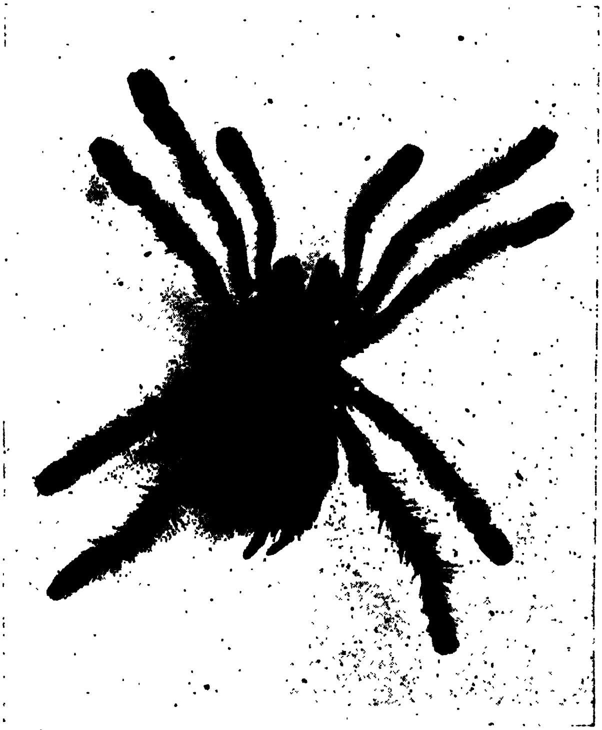
worth recording. The species was Mygale avicularia, or one very closely allied to it. The individual was nearly two inches in length of body, but the legs expanded seven



Pisaurus mirabilis — Atypus subseri — Aranea adianta

THREE INTERESTING EXAMPLES OF SPIDERS FOUND IN THE BRITISH ISLES

inches, and the entire body and legs were covered with coarse grey and reddish hairs. I was attracted by a movement of the monster on a tree-trunk; it was close beneath a deep crevice in the tree, across which was stretched a dense white web. The lower part of the web was broken, and two small birds, finches, were entangled in the web. One of them was dead, and the other lay under the body of the spider, not quite dead, and was smeared with the filthy liquor or saliva exuded by the monster. I drove away the spider, and took the birds, but the second one soon died."



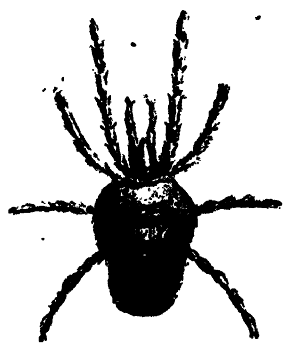
A FALSELY ACCUSED SPIDER—THE TARANTULA

A recent travel record contained a lively description of an attempt to kill one of these monsters which had made its home in a hut occupied in the Brazilian wilds by an Englishman. As it patrolled the inner wall of the hut, he slung a book at it. The spider leapt six inches aside, avoided the missile, and remained motionless. The man got up and aimed a blow with his fist. Again the spider leapt the same distance aside, dodged the blow and stood on guard. The blow was repeated again and again until the man's fist ached, but each time, with geometrical accuracy and precision, the hideous intruder did its six-inches leap to one side or the other, always to safety. The man gave it up, declaring that the only weapon with which to encounter a Mygale is a frying-pan with a diameter of at least thirteen inches!

The thickness of the Mygale's web is not without parallel. There are other tropical spiders which make webs stout enough to catch birds; and it is on record that one web contained a young mouse, which, ensnared as it ran along the ground, was girt about by separate threads of the spider and hauled four inches up into the web, where, after surviving for ten hours, it died. Snakes of small size, and a fish three inches in length, have been

captured by the same means. Moseley mentions that a full-grown and healthy, glossy starling was brought on board the "Challenger" after having been rescued from the web of a great yellow spider. The same observer states that at Cape Verde he found the twigs of the tamarisks actually bent down under the pull of the web of the big yellow spider Nephilia; while at a later stage of the voyage he received from Madeira specimens of the lizard-eating spider, Lycosa. Moseley fed his on cockroaches!

But for the wonders of web-making we need seek no farther than our own gardens, where the garden-spider, malevolent queen that she is, devouring her lover with as little compunction as if he were a blue-bottle fly, is quite supreme in artistic and effective web-spinning. Fragile though her web appears, it is a structure of marvellous relative strength; and with all its foundation lines, on which the whole is hung, the radii that intersect the centre, the inner spiral, and the more elaborate and greater outer spiral, the whole dotted with some ninety thousand globules of viscid matter which imprison the lightest wing that touches it—with all this labour she begins and ends her task in five-and-forty minutes. That is, when she so wills. She may spin out the work over four or five hours, but the actual business of building takes no longer than the time mentioned.



THE SCARLET MITE

Where instinct begins and ends in this process we do not know. One thing certain is that the webs of the garden-spider are not always alike. Each web seems adapted to meet some special requirement, whether as regards climatic conditions, site, abundance and character of insects on the wing. Two good naturalists who have been making observations in the New Forest during the past summer assert that they found a web differing slightly every day that the weather changed, as though the spider had prepared in advance for the conditions to come. But unless one watched for twenty-four hours a day for a succession of days it would be impossible to say that the structure was not varied after the changes of the weather, not in anticipation of them.

There is still much doubt as to the extent to which the spider relies on hearing and sight. Some writers believe that the hairs on the legs and palpi of the spider have an auditory function, and that the sight of the six or eight eyes is efficient. The writer's own experiments yield results entirely according with those of M. Forel, who believes that the spider sees little and hears less. That its tactile sense is highly developed there is not the slightest doubt. The slightest vibration of its web conveys a message, but that message is felt, not heard. The experiments with the tuning-fork, whose vibrations the spider has been supposed to hear, undoubtedly affect the spider only in so far as it feels the vibrations. The throbbing air actually strikes upon the entire body. An hour ago the present writer experimented with a large house-spider. As it moved across a boarded floor the faintest tap on the wood sufficed to cause it to feign death, but a loud snapping of the fingers, at a distance not too great to be heard, but yet not near enough to cause air-waves to be felt, was unnoticed. A barely audible tap on the floor conveyed a vibration which the spider was clearly able to feel; the detonation caused by the fingers, though loud enough to be heard in every corner of the room, passed unnoted. So, when an insect enters the web, the spider feels rather than hears the disturbance created.

A TICK THAT INFESTS FALLOW DEER

When a fly is enmeshed, the spider, warned by the vibrations of the web, leaps down her silken cable, and, if she be not hungry, envelops the hapless victim in a sort of cocoon, and hangs it up, buzzing dolorously, looking like a tiny ham on a farmhouse ceiling. But when the more active struggles of a wasp set the net trembling, the spider, without going close enough to investigate, spins a long line round and round and round the prisoner, securely binding it before she approaches. And one has noticed that when a powerful insect is caught, and the web is threatened, the spider will seize a strand which appears likely to be torn from its anchorage, and pull on it with all her strength.

M. Forel adduces several points of evidence to prove that the spider does not see distinctly, but none more notable, perhaps, than an experience of the present writer with a number of spiders in a large "live box." The results were certainly instructive so far as the spider as a diurnal animal is concerned. Seeing that it is day-flying insects upon which the spider has in the main to rely, this is a pretty good test, although she does build at night. In this box were flies as well as spiders, and the flies flew and leapt upon the spiders without let or hindrance. It was only at night, as a rule, that the spiders ate their prey. By day they apparently did not see them—though, when a web was spun in the box, the usual course was followed. At night they probably found them either by accident or by scent—a sense, by the way, as to whose existence in the spider M. Forel is sceptical.

But the strongest evidence as to the weakness of vision in the spider came from the actual meeting of spider with spider. Again and again two spiders, advancing by different routes, would blunder, head-on, into one another, and collide as helplessly as bats in sunlight. The moment they did so, without any attempt at recognition, such as ants would make, both would leap back in the greatest agitation and terror, and crouch an inch apart, feigning death for all they were worth. It is difficult to reconcile this with the apparently well-grounded theory that the fantastic display of colours and other attractions by the male influences the female in her choice of a mate.

We have not yet solved nearly all the spider problems. It must suffice for us that the family is one of the most remarkable in existence, and, for all its repulsive features, it must be awarded the first place in esteem for the marvel of its home-making, in water, in air, in human habitations, in the desert, and in the tangled forest. We must not forget that, though the spider is a terrestrial animal, it is also a great traveller in early life. Probably it was the first of aeronauts flying by artificial means. Every summer millions of little spiders, seeking new homes beyond the reach of their cannibalistic kin, set sail for a great adventure. Throwing out a web of the utmost fineness, to be caught by the wind, they tightly draw up their legs, and, clutching their gossamer parachute, away they go, borne by the breeze, sailing wheresoever the wind will.

FOES TO AGRICULTURE—COMMON MILLIPEDES

We pass over the false scorpions and false spiders and the harvest-men—the spider-like creatures with tiny bodies and legs of inordinate length—to reach the mites and ticks. These are a multitudinous group, many of them parasitic, and producing great discomfort and bodily ill to their human and animal hosts. Others, such as the red mite, which plays havoc with hops and indoor growths such as the forced strawberry, causing in the latter that faded, spotted appearance of the foliage which they have drained of sap, are among the most familiar. This red mite just cited is the Tetranychus telarius, and not to be confounded with another red mite, Dermanyssus avium, which infests poultry and neglected cage-birds. The worm-like mites include the gall-mites, which do serious injury to such fruits at the black currant. The ticks include a parasite which affects sheep, others which attack birds, mammals.

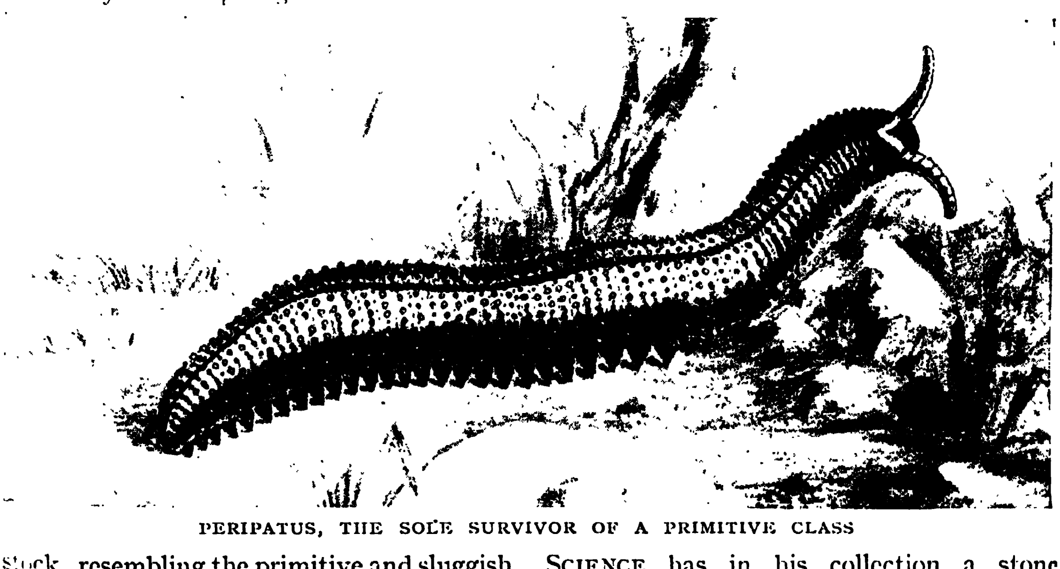
and reptiles, while another infamous family produces mange and itch. Yet another form, the so-called tongue-worms, enter the nostrils of the dog, whence the eggs are sneezed out, to fall upon grass and be luminous centipede belongs. Many of the tropical species are possessed of a serious stinging weapon, the effects of which are severe. The least-specialised centipedes are the Symphala, of which one genus, the

A TROPICAL CENTIPEDE REPRODUCED IN ITS ACTUAL SIZE

eaten by hare or rabbit, where they hatch and mature and establish themselves in the liver of their host. If this new host, or any affected part of it, be eaten by the dog, the adult condition is assumed in the latter, the parasite penetrating the digestive tract, and finding its way through the blood to the nose, where the life-cycle begins again.

Our chapter closes with the Myriapoda, a class comprising the centipedes and millipedes. Extinct forms clearly indicate that they have sprung from a common Scolopendrella, in spite of their wide distribution in Europe, America, and Asia, preserve for us the likeness, little altered, of the lowly stock from which they originated.

The millipedes are all vegetable feeders, and some of them do considerable damage to the roots of crops, so that they are called false wireworms, the latter being the larval form of true beetles. The class as a whole is an ancient one, and is abundantly represented in the rocks. It may be of interest to mention that the Editor of POPULAR



PERIPATUS, THE SOLE SURVIVOR OF A PRIMITIVE CLASS

stock, resembling the primitive and sluggish Peripatus, which is still with us, a deeply interesting living relic. The centipedes are carnivorous, and harmless in this country. It is to the Geophilida that the well-known SCIENCE has in his collection a stone cannon-ball from the Spanish Armada upon which remains the perfect matrix in which a millipede sank to its death when that cannon-ball was mud.

THE SYMBOLICAL PICTURE OF ST. JOHN THE BAPTIST AS A BOY, BY SIR JOSHUA REYNOLDS

THE GREATEST MEN OF ALL

A Study of Genius, and the Foolish Fallacy that Genius and Insanity are Closely Allied

THE CLEARER PRESENCE OF GOD MOST HIGH

We must not leave the study of man as a whole without some attempt to appreciate those exceptional manifestations of humanity which we call genius, and which have often been regarded as superhuman, so far do they transcend the ordinary capacities of man. We do not believe that these manifestations are superhuman—unless, indeed, man himself be more than what we commonly look upon as human flesh. We regard them as specially salient cases of manhood, as showing, more clearly and completely than in ordinary cases, the true nature of man. Our study of his species would be absurdly inadequate if we took no cognisance of its highest and most perfect instances, in which the essence, the *differentia*, of man, as compared with all other forms of life, becomes most manifest. Perhaps we can indeed learn more of the true nature of man from these exceptions than from the more familiar instances.

There are those who think otherwise, and they have to be reckoned with. In the nineteenth century we find two notable men, vastly different in temper and training, who stand for diametrically opposed opinions of the nature of genius. Those men were Carlyle and Lombroso. To Carlyle's view and estimate of the man of genius we shall return in concluding this chapter; it is one of those portions of nineteenth century philosophy which are still fit for the 'teens of the twentieth. Lombroso's view must here be dealt with before we proceed to the chief question at issue, which is the psychology of genius, a question upon which a great English student, Mr. F. W. H. Myers, has much enlightened us.

Lombroso's theory of genius was that it is a form and manifestation of insanity. This idea has gained great currency in a cynical age, when anything that belittles greatness is comfortable to the small. In connection with it we commonly hear quoted the poet's familiar couplet:

> Great wits are sure to madness near allied,
> And thin partitions do their bounds divide.

Lombroso's views, expressed in his book "The Man of Genius," and in many others, have made themselves famous everywhere, having been much helped by the efforts of his distinguished pupil, Dr. Max Nordau, whose book "Degeneration" is one of the most widely discussed and read among quasi-scientific works of our time. The public not unnaturally supposes that the views of authors so brilliant, famous, and positive are really authoritative, and there is no assembly of intelligent people in which this view of genius is not expressed as that which is really held by science.

It is nothing of the sort. Sober and responsible men of science are not heard by the general public, and are not discussed by "literary critics," while any wild statement is at once commented upon and given the widest publicity—as, for instance, the recent assertion that "in fifty years' time the ratio of the sane to the insane will be as one to one." Students must not rest content with such violent and entirely baseless assertions. In the case of genius, we shall do well to study such volumes as Sir Francis Galton's "Hereditary Genius," Dr. Havelock Ellis's "Study of British Genius," and Mr. Myers's "Human Personality and its Survival of Bodily Death," before we are confident that we are aware of what science has to say upon the subject.

If we are to require some scientific accuracy of thought and language, we shall begin by describing genius as supernormal, which is an entirely distinct word from morbid. The two, however, are often confounded, in organisms and in conduct. The man who does not act conventionally may be condemned as a sinner, when he is really

that very much rarer sort of person called a saint. Of course, he is abnormal, because few people are saints, and the many determine the *norm*, but his conduct is not therefore diseased. Similarly with genius.

Of course it is other than normal, or we should not be discussing it, but that does not entitle us to call it morbid. No doubt this is the easy course. Dr. Nordau does not like Wagnerian melody, so he simply calls Wagner a "higher degenerate," and there you are! The greatest Life ever lived was not as the life of others, and so the simple and satisfactory explanation was, "He hath a devil."

The Total Inadequacy of the Theory of Genius as Degeneration

Modern pseudo-science, as represented by Lombroso and Nordau, has simply taken up this old cry of the crowd against the genius, "He hath a devil," and has restated it with an array of polysyllables which may convince the ingenuous of its truth.

But if we are to be scientific, we shall see very quickly that our task is not an easy one. Before we define a man as insane—that is to say, not sane—it is obvious that we require a definition of sanity; and the remarkable fact is that we have no definition of sanity, and that no one has yet written us a book upon the subject. This literature of insanity would fill a huge library, but not one volume upon sanity, of which insanity is simply the negation, yet exists. The law has a fatuous theory, to the effect that knowledge of the difference between right and wrong constitutes sanity and responsibility; so that, if a criminal is "aware of the nature of his act," he is held responsible. Philosophers would reply that, if knowledge of the nature of right and wrong is required for sanity, nearly all the world is mad; and alienists know that insanity is not a condition of the reason at all, and that hosts of insane people are as well aware of the nature of good and evil as any of the sane.

The Want of a Standard of Sanity in the Writers on Degeneration

The first objection, then, to the theory of Lombroso and Nordau is that they have no standard of sanity. In fact, their writings are as scientific as the remark of any of us upon the behaviour of anyone whom we dislike or do not understand—"the man's mad." Of course, mediocrity cannot understand genius; and, of course, the behaviour of genius must be different from ours; its standard of values must be different from ours; and so we can put ourselves in the right by calling genius mad, thus putting it in the wrong.

The poet's couplet is, in fact, far nearer the truth than the pseudo-science of today. The man of genius is very often "near allied" to the insane person, in the sense that they resemble one another, and agree in differing from ordinary people, in certain respects. But this does not make them identical, except in the eyes of people who are content to judge by superficial appearances, which is what science does not do.

We should remember that psychology is only in its infancy. People talk of meteorology as "the Cinderella of the sciences," but the study of the abysses of atmospheric space is child's play compared with that of the abyss of the human mind. In years to come, men will marvel at the fashion in which we spoke of insanity and genius without any real knowledge of the elements of the problems we were considering. It behoves us to be more humble.

In the first place, the time has surely gone by when we have any right to use such a vague term as genius as if it corresponded to a definite entity in the world of fact. To some extent we cannot help doing so, and may, indeed, do so without harm so long as we keep to certain generalities.

The Absurdity of Confounding as Similar the Extremes of Psychology

But the outstanding objection to the treatment of genius by the school of Lombroso, as also by the host of literary and other critics who make no claims to scientific authority, is that the same word is used to express the psychological characteristics of men so different as, say, Goethe and Edgar Allan Poe, Newton and Keats, Leonardo da Vinci and Chatterton, Bach, Beethoven, Handel, and Schumann.

No one will question that Milton was a poet of genius; no one would have the stupidity to declare that he was insane. No one will question that Lord Kelvin was a man of the highest mathematical genius, and entirely sane; but what possible service can be rendered to science by calling Kelvin a genius and Aubrey Beardsley or Oscar Wilde a genius, and then proceeding to generalise as if we had a scientific definition? Yet this is the general practice; and in the name of science it is necessary to protest that the kind of definition which simply declares that St. Francis of Assisi and Napoleon Buonaparte were examples of genius is of no value at all for science or for logic. There is no better instance in the whole realm of thought of what Bacon

rightly condemned as the power of words over the mind and the injury which these "idols of the forum" do to those who cannot detect and avoid them.

The forms of what we call genius are, in fact, as varied as are the forms of mediocrity and talent. Nor is there any absolute difference between mediocrity and genius. Genius merely exhibits, in higher degree, those powers which are displayed, in some degree, by large numbers of ordinary men. We can nearly all invent tunes, some better or worse than others; only Schubert and Wagner and Bach invented the best of all. We can all write verse of sorts, we can all conceive poetic ideas; only Shakespeare was more so. We can all perform simple mathematical processes; only Newton and Kelvin could carry more in their heads at a time, and could notice new possibilities where our powers of comprehension and invention stop.

There can be no doubt that, along with the exceptional powers of genius in an infinitude of directions, there may often go certain mental and moral characteristics which seem closely allied to those of insanity. But we should do well to try to understand these everyday phenomena of insanity, as they are displayed by the inmates of lunatic asylums all over the world, before we presume to label genius in this off-hand manner.

The Light Thrown on Insanity by Recent Searching Studies

Thanks to the profound and searching powers of Professor Freud, of Vienna, we are now gradually reaching truer ideas of the psychology of insanity than ever before. These ideas throw much light upon the psychology of ordinary people as well, and they will ere long help us better to understand the psychology of genius. Perhaps the briefest way in which we can define the great contribution of Freud to our knowledge is to say that he begins to direct us to the hidden part of the mind of the insane—or the sane—from which spring, quite reasonably, naturally, inevitably, the modes of behaviour which we thought so mad, because we did not perceive the hidden springs of conduct. Once we have the key, the piece of behaviour seems quite reasonable, the delusion seems logical and inevitable, from the premises which are in the insane man's mind, but of which we were not aware.

Similarly, if we had the key to the mind of the exceptionally endowed man whom we call a genius, we should see that his behaviour, his scorn of the world and its notions, his intense anger over what seems a small cause, and so forth, are the natural and logical consequences of the ideas, the interests, the scale of values which he has in his mind, and which are different from ours just because he is what he is and we are what we are. He may often be inclined to think all the world mad, and from his point of view he may be right, or at least as right as we are in thinking him so. At any rate, we have not begun to understand him unless we grasp the truth that *the key to the conscious is the unconscious.*

The Mistake of Judging Insanity as a Simple Disease of the Brain

Having come so far, we are ready to learn what Myers has to teach us. His great book was published two years after his death, in 1901. In some ways it was before its time, even though the Society for Psychical Research had been founded as much earlier as the year 1882. Orthodox science was still dominated, less than a decade ago, by the purely mechanical and physiological view of man which prevailed in the latter part of the nineteenth century. Insanity was looked upon as simply a disease of the brain, just as jaundice is a disease of the liver. The essential problems of human personality were ignored. Consciousness was medically and physiologically regarded as a function of the brain, and the existence of the sub-conscious mind was overlooked in the schools.

Such a thing as the study of human personality was regarded as outside the pale of real science. The brain could be studied, indeed, for it is a material thing, and therefore legitimate material for "positive" or "objective" science. But personality, not being material, and being hard to define and comprehend, was best left on one side altogether. "Hamlet" without the Prince of Denmark was the order of the day in the study of Man.

The World's Indebtedness to the Psychology of the late F. W. H. Myers

But Myers and the school which he largely helped to found were keeping the flag of psychology flying all the time. They did their best to observe and record certain phenomena, displayed by human beings, with which orthodox physiology would not be troubled, and yet which were undoubtedly facts of Man. If those who read the book which Myers left behind him at the time of its publication would now return to it after reading Bergson, and the contributions to psychology which we owe

to Freud, they would be astonished to discover how much we really owe to Myers, with his clear conception of the self, or the part of the self, that lies below the threshold of consciousness, and that is therefore often called the subliminal—*i.e.*, under-threshold—part of the personality. All this, which sounded like mysticism or fiction to many neurologists of a decade ago, has already entered into their exposition and interpretation of the facts of abnormal mind.

With no uncertain note does Myers, himself a poet and prose-writer of genius, define *his* view of genius, in the sharpest contrast to that of Lombroso and Nordau. Not only does he assert that true genius is, as genius, if not normal, then not morbid but more than normal, but he also states the theory of the activities of genius which we must try to define as closely as possible, for it is the nearest statement to the truth that has yet been attained. "What type of man," says Myers, "is he to whom the epithet of *normal*—an epithet often obscure and misleading—may be most fitly applied? I claim that that man shall be regarded as normal who has the fullest grasp of faculties which inhere in the whole race. Among these faculties I count subliminal as well as supraliminal powers—the mental processes which take place below the conscious threshold as well as those which take place above it; and I attempt to show that those who reap most advantage from this submerged mentation are men of genius."

The Scientific View of Genius Defined by Myers

Such is Myers's preliminary statement of his case. He gives his view in more detail.

"Genius—if that vaguely used word is to receive anything like a psychological definition—should rather be regarded as a power of utilising a wider range than other men can utilise of faculties in some degree innate in all; a power of appropriating the results of subliminal mentation to subserve the supraliminal stream of thought, so that an inspiration of Genius will be in truth a *subliminal uprush*, an emergence into the current of ideas which the man is consciously manipulating of other ideas which he has not consciously originated, but which have shaped themselves beyond his will, in profounder regions of his being. I shall urge that there is here no real departure from normality; no abnormality, at least, in the sense of degeneration, but rather a fulfilment of the true norm of man, with suggestions, it may be, of something *supernormal*—of something which transcends existing normality as an advanced stage of evolutionary progress transcends an earlier stage. . . . The man of genius is for us the best type of the normal man, in so far as he effects a successful co-operation of an unusually large number of elements of his personality, reaching a stage of integration slightly in advance of our own."

For Myers, we see, the man of genius is one who has the most efficient grasp and control of all the parts of his personality. In his own words, "Men of genius, whose perceptions are presumably more vivid and complex than those of average men, are also the men who carry the power of concentration furthest, reaching downwards by some self-suggestion which they no more than we can explain, to treasures of latent faculty in the hidden Self."

Extraordinary Evidence of Latent Mind-Power in Arithmetical Prodigies

Here, of course, we require the scientific evidence for this view of genius, and it is certainly forthcoming. Myers began by citing the case of "calculating boys," arithmetical prodigies, such as the astonishing Tamil boy, whose powers were discussed in the newspapers in 1912. These children and youths—it is to be noted that their power usually disappears in later life—can perform, almost instantaneously, the most astonishing arithmetical feats. On inquiry it is found that they do not consciously calculate. The answer "comes into the mind" by "inspiration." Of one of these remarkable persons, Mr. Bidder, it was said, "He had an almost miraculous power of seeing, as it were, intuitively, what factors would divide any large number, not a prime. Thus, if he were given the number 17,861, he would instantly remark it was 337×53. . . . He could not, he said, explain how he did this; it seemed a natural instinct to him."

Similar Evidence in the Higher Realms of Thought

The case is the same in the higher realms of psychical product. The great mathematician Arago would let a new proposition alone, "and next day I would be astonished at understanding thoroughly that which seemed all dark before." The philosopher Condillac had the same experience. Composers of music and poets have wakened with themes or lines in their heads which could not be reached by their conscious efforts before sleeping. Alfred de Musset said: "One does not work—one

listens; it is like an unknown person who speaks in your ear." Lamartine said: "It is not I who think; it is my ideas which think for me." As for Socrates, we all remember how he attributed his ideas to the communications of his "Dæmon."

Similar evidence could be cited to any extent. M. Ribot, the great French psychologist, sums up the facts as follows: "It is the unconscious which produces what is commonly called inspiration. This condition is a positive fact, accompanied by physical and psychical characteristics peculiar to itself. Above all, it is impersonal and involuntary; it acts like an instinct, when and how it chooses; it may be wooed, but cannot be compelled. Neither reflection nor will can supply its place."

There is a much too celebrated and familiar definition of genius, due to Carlyle, as "an infinite capacity for taking pains." We now see how exactly that definition expresses what genius is not. The late Sir George Darwin, the famous mathematical astronomer, and son of an illustrious father, perfectly illustrated the high degree of efficiency which can be attained by that infinite capacity for taking pains which he inherited from Charles Darwin. George Darwin mostly used laborious and conscious arithmetical processes of an obvious kind, and he employed them for many hours a day throughout his life, very often finding that days and weeks of labour had been wasted, but sometimes reaching valuable conclusions. He had great mathematical success without a trace of what can be called genius. Without his infinite capacity for taking pains he would have achieved nothing. Let us consider the number 17,861. By sitting down to it, by conscious effort and application, we can in time ascertain its factors. When the number was named to Mr. Bidder, the famous Q.C., he replied "337 × 53" at once, without any "pains" at all. That was a case of arithmetical genius. Another such would give, in a few seconds, an answer to a multiplication which involved a row of *forty figures*, and during those few seconds he would talk about the weather, or whatever happened to be going. There was no capacity for taking pains there. Taking pains is a conscious process, perhaps the most conscious of processes. The genius, like Bidder in his small way, like Newton or Kelvin, and unlike George Darwin, "sees" the answer, the new method, the real key to things, "by inspiration." It "comes into his mind," as immortal tunes came into the mind of Schubert on the instant that he read Shakespeare's verses "Who is Sylvia?" or "Hark, hark, the lark!"

THOMAS CARLYLE
The sculpture by Sir E. J. Boehm at the National Portrait Gallery. Photograph by Emery Walker

But the composer who has no genius, only an "infinite capacity for taking pains," goes to work differently. He reads the verses over carefully, and considers the salient words, "hark," "lark," "heaven's gate," and jots down ideas for the best musical representation of calling attention to the lark's song, and of the celestial gate (probably a tinkling accompaniment high up in the treble). Then he puts these things together, and constructs his song, as a bicycle is constructed by the assemblage of its parts. The song, or the poem, or the play, or the picture is, of course, "machine-made." It may sell, it may even please for a time, but ultimately it is just nothing. There is no genius in it.

No doubt it seems very unfair that industry and application, without genius, should be so hopelessly left behind by the least breath of the authentic thing, but it is so. Many men and women throughout the world live by writing stories, and their great need, of course, is plots. They jot down ideas in notebooks, talk them over with friends, read existing stories, search newspaper paragraphs, and so forth. Robert Louis Stevenson was endowed with genius, however, which exactly answered to Myers's definition. He would go contentedly to bed o' nights, and in the morning there was his new tale, all ready—and very hard to beat. He has told us all about it in his chapter

on Dreams, published in that wonderful collection of essays "Across the Plains." He talks of the "little people who manage man's internal theatre," and he says: "They have plainly learned, like him, to build the scheme of a considerate story and to arrange emotion in a progressive order; only I think they have more talent. And one thing is beyond doubt—they can tell him a story piece by piece, like a serial, and keep him all the while in ignorance of where they aim." Many of us have wakened with vague recollections of extraordinary incidents, dialogues, and the rest, which were presented to us in our sleep, but we cannot retain them. Perhaps they would be Stevensonian if we could. But the contrast between the man of genius and the ordinary worker shows itself in this case of story-writing, just as in the case of a Kelvin and a George Darwin, a Schubert and a composer of the ordinary "royalty ballad."

Wordsworth as an Illustration, at Different Times, of Industry and of Genius

The great poet William Wordsworth admirably illustrates for us, in one individual, both conditions of production. Especially in childhood and youth, as he hints in his greatest poem, he had periods of what we commonly call inspiration, when he seemed "rapt" away from the worldly environment of his body, and came into communication with other things. As he grew older these periods of communication with his subliminal self became rarer, and finally ceased altogether. "The lamp of genius," said Schiller, "burns quicker than the lamp of life." In most of us the fact dies young, and the true significance of childhood in this connection must be referred to ere we conclude. But Wordsworth did not stop writing poetry when inspiration failed. On the contrary, he displayed an "infinite capacity for taking pains," and throughout his long life of eighty years produced an enormous mass of competent verse, but he wrote practically no real poetry after the year 1808. For the last forty years of his life he was only a skilled and patient manufacturer of verse, with an infinite capacity for taking pains, but no genius.

Those periods during which ideas, images, noble phrases surged up into his conscious or "supraliminal" mind from the subconscious had practically come to an end with advancing years. His genius, "that happy mixture of subliminal with supraliminal faculty," had come to an end. The difference between the two kinds of product stares every reader in the face when he comes to take Wordsworth's poems and reads them chronologically.

The student should certainly consult Myers's great pages for himself. But even without his help we can begin to understand how the "Dæmon" of Socrates was really his subliminal self, communicating with the conscious self of that marvellous man of genius.

Joan of Arc an Example of the Subliminal Uprush of Genius

Similarly, we realise that the voices and their commands which were heard and obeyed by Joan of Arc were the subliminal self of that girl of genius. The convenient explanation, as usual, was "She hath a devil," and so we burnt her alive. If we wish to obtain further first hand *data* as to what happens in the course of that "subliminal uprush" which is the inspiration of genius, we should consult Wordsworth's "Prelude," in which the poet has deliberately set himself the task of describing the poetic and inspired state, and which is thus, as Myers has pointed out, of extreme psychological interest as an authoritative document on the subject.

Anatomists and biologists of today tell us that the child is the highest form of the race, and indicates the direction towards which it is progressing, whereas the physical details that distinguish the adult organism are usually degeneracies, and reversions to lower types, like the hairy face of the adult man. We may now begin to see that this is true, in some respects, of the psychical order. Wordsworth, and Vaughan before him, argued that the child "trails clouds of glory," is "nearer heaven," as Hood said of himself as a boy. We all know the lines:

> Not in entire forgetfulness,
> And not in utter nakedness,
> But trailing clouds of glory do we come
> From God, who is our home.

"For of such," said the Founder of Christianity, "is the Kingdom of Heaven."

The Highest Hours of the Highest Minds Men's Rarest Heritage

The study of genius suggests that the child is the natural, spontaneous genius, and that thus the genius in general is the type towards which man ascends. As Myers has admirably said, "Childhood is genius without capacity; it makes for most of us our best memory of inspiration and our truest outlook upon the real, which is the ideal, world." The men of

genius have grown into manhood retaining the privilege of the child, and developing the capacity for making that privilege effective. In them, to quote the end of Myers's great chapter:

"We can catch that sense of self-fulfilment in self-absorption, of rapture, of deliverance, which the highest minds have bequeathed to us as the heritage of their highest hours. These our spiritual ancestors are no eccentrics nor degenerates; they have made for us the sanest and most fruitful experiment yet made by man; they have endeavoured to exalt the human race in a way in which it can in truth be exalted; they have drawn on forces which exist, and on a Soul which answers; they have dwelt on those things 'by dwelling on which it is,' as Plato has it, 'that even God is Divine.'"

Here speaks something higher than knowledge, which is Wisdom. All the knowledge we can obtain supports it. The nature of genius is clearly seen to be as Myers asserts. Cleverness, talent, and capacity may construct, combine, and manufacture; but genius creates. Cleverness puts things together from without; genius brings into being from within. Cleverness tries to make an automatic machine by the combination of materials. Life makes its machinery from within, unfolds it from the germ, in which, indeed, it was not.

Genius the Presence in the Individual Man of the Universal Creative Mind

That is the method of genius. It is creative, and the man of genius is a creator, bringing new things into the world, as Life brings new species into the world. If now we regard Life as essentially psychical; if we look upon the "subliminal self" of every man as the portion of the Universal Mind which displays, or conceals, itself in him, we shall be prepared for the noble and profound definition of genius which we owe to Carlyle, and which is as little known as his irrelevant definition is well known. "Genius," said Carlyle, "is the clearer presence of God Most High in a man." "Dim, potential in all men," in the man of genius it becomes "clear, actual." Hence the mysterious, inimitable character of its doings. In its achievements we see Creative Evolution at work in its highest product, making him higher still.

If our understanding of genius be sound, we see what a place this great gift takes in the evolution of humanity. Here, again, Carlyle is proving himself to be the sound guide. Bacon thought that his scientific method was to "level men's wits," so that anyone could make discoveries by the honest application of his machinery. The nineteenth century as a whole thought much the same. But genius has been genius in the realms of philosophy and science since Bacon discussed the inductive method of thinking, as before; and the nineteenth century view of salvation by legislation and mechanism and universal education has long since proved to be a delusion.

The Essential Truth of Carlyle's Gospel of Hero-Worship

Only "soul" can save; the "soul of all improvement is the improvement of the soul." The universal tendency to "hero-worship," on which Carlyle wrote so eloquently seventy years ago, has a valid use and "survival-value." It is the heroes, the men of genius, that guide and guard and advance mankind, and the best that the rest of us can do is to recognise and value them as we should.

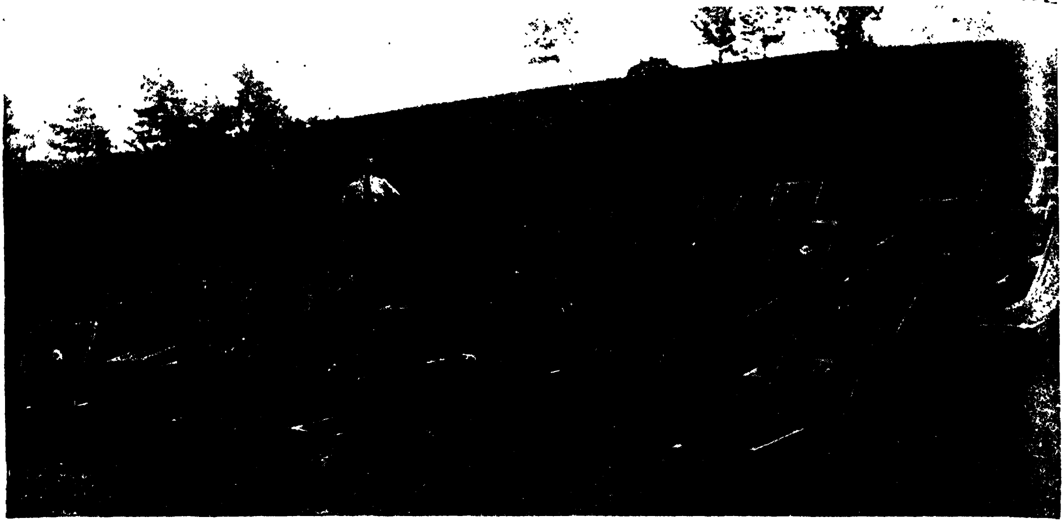
As Carlyle said: "Universal History, the history of what man has accomplished in this world, is at bottom the History of the Great Men who have worked here. They were the leaders of men, these great ones—the modellers, patterns, and in a wide sense creators, of whatsoever the general mass of men contrived to do or to attain; all things that we see standing accomplished in the world are properly the outer material result, the practical realisation and embodiment, of Thoughts that dwelt in the Great Men sent into the world; the soul of the whole world's history was the history of these."

"There is but one temple in the universe," says Novalis, "and that is the Body of Man. Nothing is holier than that high form. Bending before men is a reverence done to this Revelation in the Flesh. We touch Heaven when we lay our hand on a human body."

The Something in Man Older and Greater than Himself

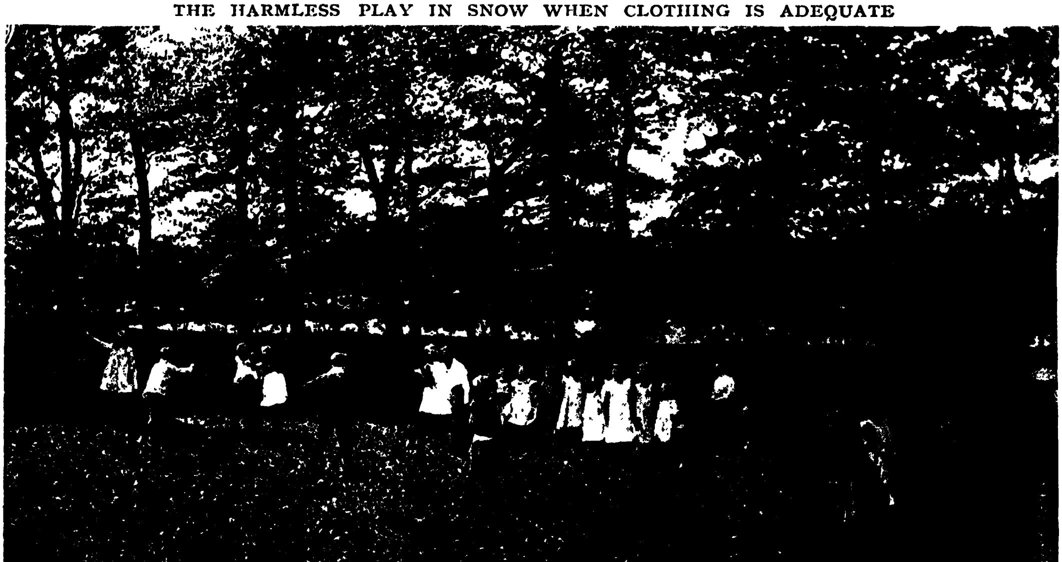
These words ring very true to the modern student of man, and especially of man in his highest forms, who believes that the Mind which is in man, and which made man, is part of the Mind which is behind all things. And the best evidence for this view of man is furnished by the psychological study of the most characteristic facts of the highest types of men, and the mode in which they do what they do by the spontaneous and creative Power of Something which is in them, but is older and greater than they.

GIVING THE POOREST CHILDREN A CHANCE



THE REST-HOUR IN AN OPEN-AIR SCHOOL FOR DELICATE CITY CHILDREN

THE HARMLESS PLAY IN SNOW WHEN CLOTHING IS ADEQUATE



THE PLAY-HOUR IN THE MOORLAND GROUNDS OF A NORTHERN CITY'S OPEN-AIR SCHOOL

The top and bottom photographs on this page are by courtesy of Dr. Ralph Williams

HEALTH IN CHILDHOOD

The Course of Care by which Children Will Grow Up Naturally Well and Strong

GENERAL PRINCIPLES AND SPECIAL HINTS

WITH everything, but with living beings above all, beginnings matter immensely. The living creature has in it at any moment the whole of the individual and racial past. If we wish to secure its health we cannot begin too soon. A chapter must therefore be devoted, before this section closes, to the physical health of infancy and childhood, in the proven belief that attention to hygienic principles at these periods will be repaid at every subsequent stage of life.

The American friends of childhood—the After-School Club and all the bodies affiliated with it—have just completed the draft of a scheme for five volumes that shall constitute a "Survey of Child Life," covering all the details of physical, mental, and moral health. This will be an encyclopædia of childhood, written by leading authorities throughout the world.

If we desire to maintain the health of a child, and if we cannot determine what child, of what ancestry, it shall be, we must at least begin with the care of its mother before its birth. Such a mother will regard herself as holy, as a veritable creatrix of life to come. A very few words suffice to define her duty at this period, for herself and her child. It is very necessary that she should be happy—as happy as possible. Especially during the last three months she must avoid every kind of strain, excitement, and unrest. Social "duties" and the like must be regarded as of no moment now. The expectant mother who takes proper care during the last three months will bear her child longer; and this means that its birth will be easier for her and its chances of life much raised.

But physical idleness is not desirable. Gentle, regular daily walking exercise is most important for the proper health of the body and for the tone of the muscles, and for the obtaining of good sleep. This is most important, and is urgently insisted upon by all modern obstetricians. We need hardly point out that the physical and psychical difference between such exercise and hard, prolonged, compulsory, manual labour is extreme, and that the one is as good as the other is bad for the expectant mother.

During the last few weeks she will attend carefully to the invaluable organs upon which her child's chances of life will largely depend; for we know, beyond dispute, that no perfect substitute for its mother's milk can be found. When the baby is born, its eyes will be immediately and thoroughly bathed and washed out. It needs no food as yet. Twenty-four hours may elapse; and during that period the baby should receive no sugar-and-water, nor any other absurd and irrelevant concoction without the sanction of Nature. Thereafter, the child should be put to the breast; and if its mother can nurse it for many months to come it will make the best possible start in life.

No child is born rickety. There is no such thing as "congenital rickets," though the phrase has been used. Nature knows better than to feed a child on what produces rickets before it is born. Every case of rickets is an *acquired* disease of malnutrition, for which someone is responsible. It may be the mother; or some dead "statesman" who forgot to have the nation's future mothers taught the elements of living when they were at school; but someone is certainly responsible. A mother should be encouraged to nurse her child herself, thus guaranteeing it against rickets - for a long time to come, at any rate.

Her vital energies have toiled for it unceasingly, day and night, for many months. She may as well complete the task to which

she has already given so much of her own life. If she wishes to prevent the child's fair promise from being blighted, her first duty is to nurse it herself. Most of the prize-winners of life were fed by their mothers when they were babies, and most of the babies that do not survive are *not* fed by their mothers. Nature has been at her task of saving babies a long time, and this is the way she has found best.

Doctors have tried everything they can invent for babies instead of their mothers' milk, and the conclusion of the whole matter is that mothers' milk is best. In France, where babies are scarce, and therefore precious, doctors tried feeding them with all sorts of things, but now they feed the mothers, and the wonderful chemistry of the mother's body does the rest.

Very often the mother thinks she cannot nurse the baby, and gives up trying, and unwise nurses and even doctors may help to dissuade her, and may say that the bottle will be better. In the end they turn out to be wrong, terribly wrong, over and over again. They should rather try to give the mother rest, peace of mind, and sensible food, with plenty of milky things, and a little meat and soups, but no stout or porter, such as doctors used to order when nothing was known about alcohol and what it does to the milk.

The Grave Unwisdom of Unnecessarily Early Weaning

Dr. A. E. Naish, who is in charge of the Municipal Consultations for Babies in Sheffield, has lately made and published a very careful study of this subject. He says that "Of all the calamities that may occur to the infant during the first week or two, by far the most serious, to my mind, is that of unnecessary weaning." And he goes on to show how often this occurs. Far too often the influence of the doctor and the nurse is thrown upon the wrong side, and it is common to find the child weaned, to its serious injury, often mortal, simply because the expectant mother has not been taught how to care for the nipples, to draw them out if they are depressed, and to prevent them from cracking. Medical students are as yet taught nothing of these things, though they are all examined in the details of "chronic hypertrophic pulmonary osteo-arthropathy," of which not one in a thousand will ever see a case.

When the mother suffers from consumption, she certainly must not nurse her baby, for that would be dangerous both to her and to it. On the other hand, the relatively trivial malady called constipation is often a cause of unnecessary weaning. If the constipation persists, the milk is apt to be affected, to the child's detriment. On the other hand, if an aperient be given, the child receives a portion of the dose, and may be upset. Therefore, the simple rule is that, by a well-chosen diet and by proper exercise during the last few months of pregnancy, the expectant mother should prevent constipation ; and then it will not be so difficult to keep things right afterwards.

But psychical causes, worry and excitement, are just as inimical to the proper establishment of nursing as is constipation.

The Effect of Mental Causes in Preventing the Nursing of Infants

Even among our domestic animals we find that alarm and excitement spoil the milk; and how much more is this likely to be true of so highly organised and sensitive a being as a woman! After childbirth many women are easily upset and depressed; and though a mother may put the best face on matters during the doctor's visit, he may find, on inquiry, that she has been in tears over some comparative trifle. This very common tendency towards loss of mental equilibrium has a serious influence, in many cases, upon so delicate a function as the production of nutriment for the baby.

Of course, some mothers really cannot nurse their babies, and then they must ask a cow to help them. But this involves serious risks, which must be guarded against. Cleanliness is all-important, for the lack of it means the growth of millions of microbes in decayed milk, which is an admirable medium for their growth. Under certain conditions cleanliness is simply impossible. No one can really clean a long-tube feeding-bottle. Such bottles may be convenient to nurses, but they are death to babies.

Infanticidal Instruments that Should Be Condemned by English Law

In Germany the long-tube feeding-bottle is forbidden by law, as it should be. In this country, the National Association for the Welfare of Infancy, which was formed in the autumn of 1912, has already passed a resolution drawing the attention of the Government to the facts, and demanding that we shall have the same legal prohibition of these infanticidal instruments in this country as in Germany.

Though the right beginning for a baby is to be fed by its mother, there comes inevitably the time when the mother's milk no longer satisfies the baby, and it must have

something more. It requires to be weaned, and very often indeed it suffers in the process, mostly because of the things we use to help it. No baby that has not completed its first year should be asked to digest any kind of starch. The baby does not have in its body the kind of digestive ferments which can digest starch, and therefore no food which contains starch is proper for an infant that is just being weaned. There is no starch in milk, but unfortunately mothers cannot be persuaded that milk is "solid nourishment," though the modern vogue of dry milk must have taught many of them.

The Overwhelming Value of Milk as a Food for Children

The chief defect in the feeding of most children from weaning until they are far past their second year is that they do not get enough milk. Milk should remain the staple diet of a child for long after it is weaned. We should remember that many savage mothers do not wean their children until they are at least two years old, and that was probably the least period for maternal nursing in our species long ages ago. The one great staple food for childhood is milk, first, last, and all the time. And its own products, such as butter and cream, are its great allies.

Though milk contains no starch, it has a valuable sugar in it; and we need not be afraid of letting young children have almost as much sugar as they feel inclined for, especially if it be the natural sugar in fruit. Sugar is a splendid fuel, with which young children can keep warm their small and therefore easily cooled bodies. Our grandparents were quite wrong in supposing that a child's fondness for sweet things was a sign of original sin. But we must certainly not use sugar to help us when we are weaning a baby, by putting it on a "comforter," and letting the baby whom we are weaning suck that. No baby should have a "comforter" at all. It is a constant source of infection, not fit to put into a baby's mouth.

The Discomforting Effects of the So-Called "Comforter"

The proper name for these abominations is *discomforter*, as can easily be shown. Sucking at the discomforter means that the baby's saliva begins to run, and this soon interferes with its digestion. Even when the discomforter is solid, the baby usually manages to suck in a certain quantity of air; and this, together with the gas produced within the baby owing to its indigestion, naturally causes discomfort, crying, and flatulence.

Recently, also, the dental surgeons have shown that sucking at a dummy teat distorts the shape of the child's mouth, making the palate grow forward, and so ruining the natural shape of the jaws. Many of the ugly mouths and projecting upper lips we see in children and grown-up people are due to the "comforter." Precious little comfort it leaves behind it when the baby's mouth is distorted for life.

A "comforter," like a pipe, establishes a habitual need for itself, so that its discontinuance involves annoyance and irritability, which its resumption relieves. But this proves nothing in favour of the original employment of either. Mothers specially tend to use the discomforter when babies are teething, but it is not worth while. The discomforter justifies its new name, by causing most, if not all, of the troubles which are supposed to be due to the teething, and for which the discomforter is supposed to be useful. The baby that is getting no starch, and that is getting plenty of clean milk, will cut its teeth with little trouble, or none at all. The bad reputation of teething, a perfectly natural and normal process, is mainly due to the stupid way in which we have been content to mishandle babies, and especially their stomachs and their mouths, in the past.

The True and Invariable Cause of Infant Rickets

There is a great delusion to the effect that rickets is only a weakness of the bones, and that, so long as they are all right (or apparently all right), a child must be free from rickets. But, in fact, rickets is a constitutional disease, caused solely by unsuitable feeding, which shows itself in a host of ways, if we know how to look for them; and it has gone a very long way before it tells upon the external appearance of the bones. Many babies have straight limbs, perhaps with plenty of fat upon them, who are rickety nevertheless. In many cases there is an excess of fat, which cannot be properly burnt up by the disordered chemical economy of the child; and these cases often deceive all but the expert, who knows how to look for the crucial signs of malnutrition.

Only the expert need study these signs; for the rest of us, it is sufficient to know how their appearance may be prevented. An abundance of fresh milk, as we have seen, comes first, and then good bread, not too starchy, but made from a good flour with the germ of the wheat-grain in it. Unfortunately, when we praise milk and its

derivatives and applications, many mothers are inclined to think of "slops," bread-and-milk, and so forth, with nothing that can possibly need chewing. Then they are sorry that their children's teeth are so poor. Of course they are poor if the child's growing body was never given to understand that teeth and chewing were to be expected of it. That is the great mistake which has been made for many years past in the feeding of young children, and then we find, of course, that nine of the nation's school-children out of ten need the dentist badly, and at once.

A child's teeth are meant to be used. Their use helps the blood to flow freely in the blood-vessels of the jaws, and so to make them and the teeth they bear as strong and well formed as they should be. Very few people know how much this means for beauty in later life. We must not feed children on slops only. They must have good, firm rusks, or toast, or crust of bread. Every doctor who has studied the subject is enraged when he sees the crusts cut away from children's bread. The crusts are richer than the crumb in nourishment, and they are invaluable as providing exercise for the teeth and jaws. Not only does this exercise help the teeth and jaws themselves, but it starts the digestion of the food in the proper way by getting plenty of saliva mixed with it before it is swallowed.

The Regulation of Children's Health by Food Possible Without Medicine

Some of the modern wheat-foods are excellent for children, both in themselves and because they need chewing. If our children are to have good teeth, properly developed jaws, and healthy mouths, we must stop feeding them on slops. And though a young child's teeth are only temporary, the better they are treated the more likely are their successors to be what generous anatomists still kindly describe as the "permanent teeth."

We have already seen that constipation in the mother is a source of danger to the nursling. Constipation in the child itself is to be regarded most seriously. A tiny infant should be most scrupulously observed in this respect, in which nearly all infants and young children give trouble at some time or other. When weaning has been accomplished, and we are doing our best to provide the baby with a suitable diet, which very likely comprises a boiled or otherwise sterilised milk, we often find that it becomes constipated. Cows' milk is a constipating thing, especially if it has been boiled. The fat or cream in it is the constituent which helps to keep the bowels active, and hence cream and butter have a special value for young children beyond that involved in their high proportion of nutrient material.

The child must not be allowed to be constipated. The next thing will be that it is poisoned, and the opposite of constipation will follow, in the attempt of Nature to get rid of the poisons which the constipation produced. But when a child is constipated we follow our usual rule with adults as with children, and begin to think of drugs first. That is where we are wrong. We should think of drugs last; and if we have done any good thinking before that we shall seldom reach them at all.

The High Value of Fruit as an Element in Diet

It is the diet that was wrong, and the diet must be attended to. A little more cream, for instance, may make all the difference.

Elsewhere in this section we have seen how valuable a part fruit may pay in the dietary of the adult. But fruit is even more important for children. We all know how useful "fruit salts" may be, but do we all know how useful the salts in fruit may be? We still fancy that fruit is a luxury, not least for children, presumably, because it is, or used to be, rather expensive, and because they are so fond of it. But fruit is a necessity in some form or other.

Orange-juice, lemon-juice, grapes, apples, prunes, figs, are all splendid things for children of all ages, to say nothing of grown-up people. Especially is this true of children who are being fed on boiled, sterilised, preserved, condensed, or dry milk. Often a teaspoonful of orange-juice twice or thrice a day has saved the life of a tiny infant, which was dying on some preserved artificial diet, just as Arctic explorers used to die of scurvy before the use of lime-juice made the discovery of both Poles possible. The pathologists have not explained how it is that lime, lemon, or orange juice will cure or avert scurvy, whether in the adult or in the form of the "infantile scurvy," first discovered by Sir Thomas Barlow, but the fact is unquestionable.

The Unvitiated Appetite of Children a Trustworthy Guide

People who have made the experiment know that children who are allowed fruit, and even cake and sweets, freely do not exceed and make themselves ill. The trouble is that, thinking ourselves so clever, we usually deprive children of these things, and

then, of course, they take too much when they do get the chance, and make themselves ill. We should trust children's appetites far more than we do. Then we should have to give them medicine very seldom indeed, and only as a last resort.

It seems to be still very generally unknown that by the Children's Act it is a misdemeanour to give a child under five years of age any form of alcohol, except medicinally by doctors' orders; and if the Act had said fifteen instead of five years it would have been none the worse. The best doctors for children nowadays, from Sir Thomas Barlow, President of the Royal College of Physicians, downwards, never allow or order them alcohol at all, either in health or illness.

As for meat, which many very young children dislike, or like very little of, they are right—that is to say, Nature is right, and we are wrong. Which is, of course, not so surprising, when we come to think of it. On the other hand, beef-teas and meat preparations have their uses in many cases, and often help the appetite and the digestion of ailing or weakly children. They are to be looked upon not so much as foods in themselves as aids to the absorption and utilisation of other foods.

Hints as to the Sensible Clothing of Children

The feeding of infancy and childhood is of transcendent importance, but there are many other factors of health which we should consider. In matters of clothing, the "golden mean," which Aristotle commended more than two thousand years ago, is still often ignored. Some mothers believe in the "hardening" system, which has frequently justified its name by achieving the stiffness of death. They send out their children inadequately clothed, forgetting how small a child's body is, how easily cooled, and how ready, in that condition, to harbour the microbes of bronchitis and pneumonia. Fashion and appearances play a ridiculous part in this connection. On one and the same cold morning in December you may see children in, for instance, Kensington Gardens, of whom one is quite bare-kneed, and wears nothing but thin socks, while another has warm stockings, plus neat and cosy gaiters, which cover the entire leg and knee. Both extremes can scarcely be right.

It is well known that the knee-joint, the largest and most complicated in the body, is specially liable to the attacks of the tubercle bacillus. The physiologist—who knows how exposed the joint is, how incapable of producing heat on its own account, and how dependent upon an ample blood supply for the purpose of keeping up its temperature—cannot believe that the exposure of young children's knees to the cold winds of winter is a safe or rational proceeding. In general, it is a sound rule *not to chill children*, or any parts of their bodies.

But it is no less sound a rule not to coddle them; and undoubtedly the "hardening school" stands for a very necessary protest against the view that children must be choked with woollen comforters and chest-protectors, and kept indoors whenever it is raining. The inevitable result of these procedures is to lower, instead of educating, the child's powers of resistance; and some day, when it is exposed to no particular degree of vital strain, it will succumb. Children should not be chilled, but neither should they be coddled.

The Need for the Open Air in Defiance of the Weather

The best rule is to provide them with abundance of clean, warm, absorbent, *loose* clothing, and then let them take the weather as it comes. For it is vitally important that children should get exercise, which they need far more than *temperately living* adults do; and the exercise which is not conducted in the open air is little better than a farce. All the distinctions between open air and mere fresh but confined air, to which attention was drawn in an early chapter of this section, are valid, even more for children than for adults. Attention was notably directed to them by Professor Leonard Hill at the meeting of the British Association in 1912; and in the address of this authority, who has devoted years to the first-hand study of the subject, the reader may find ample confirmation of the arguments already presented in this work. Man is not a mole, but an open-air animal; his young require exercise in the open air, of which all imitations are to be refused.

The Open Air as a Preventive Against Adenoids

The properly-clad child, with stout and entire soles to its boots or shoes, with hands and feet warm, and accustomed to play about in the open air in practically all weathers whatsoever, is the child least likely to catch cold, or any of the various forms of lung-infection. Not being subject to colds in early life, partly because it does not spend most of its time in a dust-laden atmosphere, this is the child that is least likely, so far as we know, to develop adenoids. It will be a nose-breather, and nose-breathers need

concern themselves very little about the weather, for they carry their protective filter and air-warmer with them wherever they go. Already, in this section, reference has been made to the importance of nose-breathing, and the grave consequences of its chief obstacle, which is the presence of adenoids of the so-called "central" variety. The so-called "lateral" adenoids do not interfere with breathing directly, but they prejudice the hearing, and greatly increase the risk of infection reaching the middle ear from the throat, and perhaps doing irreparable harm to the drum.

The Grave Effects of Adenoids, and Some of Their Causes

Since the subject was referred to early in the course of the present work, a valuable paper, entitled "What adenoids really mean to children," has been contributed by Mr. Macleod Yearsley to the "Practitioner," and a few notes may here be made from the words of this leading authority. We may remember that 8 per cent. of the nation's school-children now suffer from this complaint, as revealed by medical inspection, hitherto unfollowed by treatment. Mr. Yearsley says "Adenoids constitute one of the most frequent and grave diseases of childhood. The disorders that result from them are the cause of a marked retardation of development, and create a formidable obstacle to physical and psychical progress in the children who suffer from them. They constitute a very common affection, whilst their more remote traces are patent in numerous adults."

Mr. Yearsley argues that artificial feeding in infancy is a great cause of adenoids, because it involves unsuitable breathing on the part of the infant, unless very great care is taken; and it is indeed the fact that a great majority of adenoid cases occurs among the artificially fed, and a minimum in countries where normal maternal feeding is common. His conclusion is as follows: "Hence, in badly conducted artificial feeding, and in the use (or rather abuse, for it has no use) of the pernicious and abominable 'comforter,' there is a fruitful factor in the occurrence of adenoids."

The Need for Guarding in Infancy Against Future Deafness

As Medical Inspector to the London County Council Deaf Schools, and as a devoted student and champion of the deaf child, Mr. Yearsley should be listened to when he describes the early and neglected origin of the great number of those cases of deafness upon which quacks everywhere thrive. Here is what he says; and the parent who is not deaf to the voice of knowledge may save a child from a great disaster in years to come by listening now.

"It cannot be too vigorously stated, or too constantly reiterated, that chronic deafness in the prime of adult life depends, in the vast majority of cases, upon slow and progressive alterations, long unsuspected, because so insidious, in the middle ear. The fact that much of our normal auditory acuity is not required in everyday urban life makes this slow progress the more dangerous, for, so long as a conversation can be followed, or amusements enjoyed, the trouble passes unchallenged, and it is often not until hearing in one ear is nearly gone, and that of the other begins to go, that the patient awakens to his defect. *It is in the course of the first years of life* that the auditory apparatus is most exposed to inflammatory changes, and it is then that the foundations of chronic catarrhal deafness are laid down in the delicate middle ear, to develop insidiously and to overtake the victim somewhere about the full activity of the period comprised between the twenty-fifth and thirty-fifth years."

Deformities that Come to Children Through Undue Strain

The limbs of a young child are possessed of what is, in large measure, a merely cartilaginous or gristly skeleton. They must not be exposed to too much strain. We constantly see small children who are allowed to go about on legs which are visibly buckling under the strain. This happens not least with heavy children, where the superfluity of fat and the special weakness of the bones are both due to the familiar cause, rickets. Of course, it is a great cruelty and injustice to a child to bend its limbs in this fashion, even though Listerian surgery, years later, might straighten them at the cost of four compound fractures. The simple ways of ensuring that a child grows up neither bow-legged nor knock-kneed are two. First, no young child should be allowed to remain on its legs too long at a time; the proper and natural exercise for childhood is rapid alternation of "spurts" and rest. Second, by attending to the diet of the child we can prevent that constitutional state of malnutrition which makes the young bones easy victims of undue pressure from above.

Not much less familiar is the deformity of the spinal column due to strain and neglect, and, in some cases, to unsuitable

positions when reading and writing. These conditions are a source of income to doctors and masseurs and physical culture experts, for they are extremely intractable, and very likely to recur once they have established themselves, but they are easily preventable by parents who prefer to follow the almost costless and wholly common-sense injunctions of the present chapter. The child that is expected to use its limbs as it will, to hop and skip and jump in loose, warm clothing, in every kind of weather, and that is not expected to use its naturally long-sighted eyes at short range with lesson-books for several hours a day, will not suffer from curvature either of the spinal column or of the two columns upon which it is supported.

One of the recognised topics for discussion in regard to the hygiene of childhood is ventilation. Of course, a child's nursery and schoolroom should be airy and well ventilated. Of course, the bedroom window should be open at night. Certainly there should be as little dust as possible, and therefore as little as need be of the kind of hangings and floor-coverings from which dust is largely derived.

Deep and Prolonged Sleep a Cardinal Necessity for Children

But our discussion on the subject would be out of touch with modern knowledge if we said anything to suggest that even the very best rooms are the right environment for a child that might be getting out into the open air. That point has been established for adults; and the recent experience of open-air schools, beginning with the famous Forest School at Charlottenburg, has established it still more amply for children.

Deep and prolonged slumber is a cardinal necessity for the health of childhood. Its importance cannot be overstated, or insisted upon too frequently. Half the good of the open air, the exercise, the liberty for which we plead during the child's waking life, is that these conduce to the right kind of sleep as nothing else can. If the child is uneasy in his sleep, suffers from bad dreams and night-terrors, the facts must be examined into. Very often the cause will be found in adenoids, which interfere with breathing, and thus produce, during sleep, the symptoms characteristic of partial asphyxiation. The old fallacy that the usefulness and efficiency of sleep can be measured by the clock must be guarded against. No doubt children sleep deeply, and are often not easily roused. We assume, therefore, that noises do not very much matter, in reason, provided that the child is not actually wakened. This is a serious error, which spoils the quality and therefore reduces the value of the sleep of many unlucky children. There are careful students of the conditions of nervous development who believe that many of the phenomena displayed by the urban poor of this country are really due, perhaps above all, to the bad quality of the sleep which they obtained during childhood.

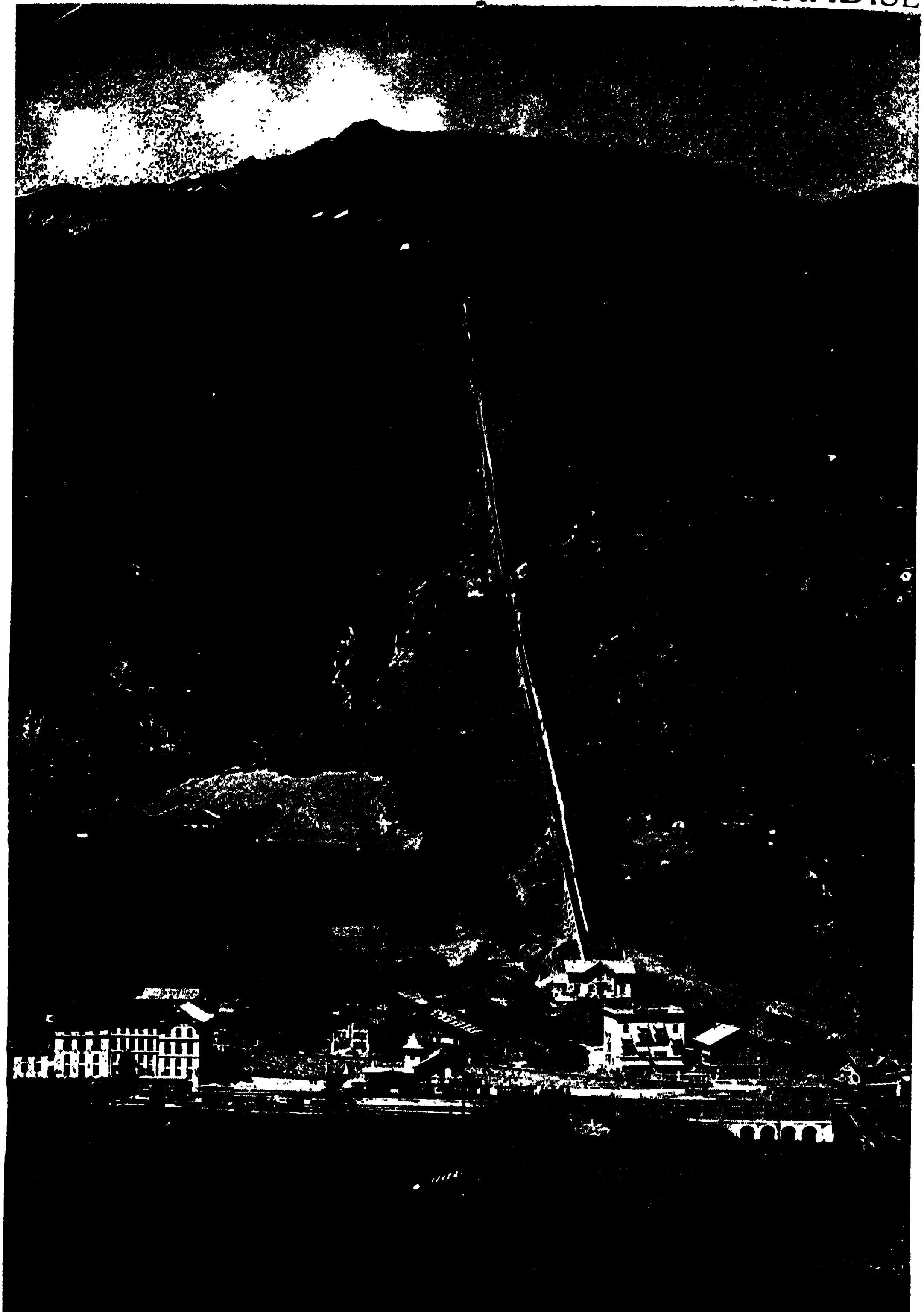
The Noises of the Night a Menace to National Health

The increasing nocturnal noise of our cities is a menace to national health, largely because it means that children do not get the quality of sleep they require, and to which they are entitled, for the proper development of the brain, and therefore of the body in general. This is a matter which will some day have to be effectively dealt with by the legislature, or by competent and progressive municipal corporations.

Lastly, it should be taught everywhere, and learnt by everyone, that the wilful exposure of children to any form of infectious disease is a *crime*, against the child and against the State. The theory underlying such exposure, which is a matter of daily practice in this country at this hour, is that, since the child must catch the disease sooner or later, it may as well have it along with its brothers and sisters, and get it over now. To this the reply is that children do not need to have their infectious diseases; and that, if we choose to protect children during their period of great susceptibility, the chances are high that they will escape the disease altogether.

The Fatal Theory that Children Must Catch Childish Diseases

Second, such diseases as measles and whooping-cough are terrible destroyers of child-life, little though most people know it. They claim their scores of thousands of young victims every year. Careful observation of the statistics shows the very simple, natural, and important fact that the death-rate from these and similar diseases, such as scarlet fever, diminishes steadily and rapidly as the ages of the patients rise. Every year that passes a child is less likely to catch these diseases, and more likely to recover if the disease is caught. But a considerable proportion of the cases and of the mortality at early ages are due to the absurd and fatal theory of parents, and to the reprehensible carelessness and ignorance of those who decided what those parents should learn when they were at school.



THE RAILWAY FROM LAUTERBRUNNEN TO THE MOUNTAIN VILLAGE OF MÜRREN

MOUNTAIN RAILWAYS

The Stupendous Engineering for Enabling Trains to Climb to the Ridge of the Andes

THE LATEST LIFT TO ALPINE SOLITUDES

WHERE man can make a path, the engineer reckons he can always make a railway. It is mainly a question of expense. If it is cheaper to lift a line over one of the great mountain ranges of the world than to bore a tunnel through the rock, the railway will climb to the region of eternal snows, and brave the avalanches of the heights. Of all the displays of human power, a great mountain railway is the most magnificent. The engineer has continually to use the mightiest energy yet discovered—the higher explosives. With dynamite and nitro-gelatine he tumbles a granite peak into a neighbouring valley, in order to form a bridge for his iron track. Arriving at a cliff so smooth-faced that a bird cannot find a footing, he will blast out a zigzag path, and send a train steaming up it. In some places, a mountain torrent will need a high bridge across it. The engineer will harness the fierce stream to a water-turbine, and get from it all the electric power necessary to work the railway. And lately the irresistible engineer has been struck by the sublime beauty of the snow-crowned heights that he was determined to conquer. Instead of defacing a famous mountain by an iron track and a clawing cog-wheeled train, he has made a tunnel to the mountain top, and sent his engine and carriages crawling up a lighted tube in the granite heart of the monarch of the Oberland.

A good many mountain railways are short, and laid for the benefit of tourists. This is particularly the case in Europe. But the highest line in the world was built as a traffic highway. It was part of a great scheme to connect the Pacific coast of South America with the markets of the Old World. About forty years ago the Peruvians were exceedingly prosperous. Enormous deposits of guano were exploited on the islands off the coast, and when these were growing exhausted an abundance of nitrate was found on the mainland. Great fortunes were made, and Peru borrowed money lavishly, and started railway-building on a grandiose scale. The most ambitious scheme of all was that of Henry Meiggs, a railway-builder from Philadelphia. He proposed to run from the seaport of Callao, lift the metals over the crests of the Andes, drop down to the highlands on the other side, and lay the railway across the plateau, until he reached the point on the Amazon to which steamers from the Atlantic could come. In this way the long and hazardous voyage round Cape Horn would be avoided, and Peru would become the chief centre of commerce on the south Pacific coast.

But only one section of this remarkable Transcontinental route has been constructed. Intestinal strife and wars with neighbouring States so undermined the credit and financial strength of Peru that there was not enough money to complete the scheme. Yet this first section remains the wonder railway of the world. The distance covered as the crow flies is only eighty miles, but the line so twists and turns and zigzags that its length is increased to about one hundred and forty miles. In the course of 107 miles the train mounts 15,865 feet into the clouds, which is about equal to the elevation of Mont Blanc. In a few hours the traveller is carried from the tropics to the neighbourhood of eternal snow, where he usually falls at once a victim to mountain sickness.

This line from Callao to Oroya is the greatest audacity in engineering science. Meiggs began it in 1870, and he built upwards very rapidly. At the end of the first year, thirty-three miles of earth-works were made, and twenty miles of line were finished. With an idea of making his task easy, the constructor followed the Rimac River into the heart

of the mountains. There, however, the stream narrowed and plunged through a defile, where the walls of the peaks dropped sheer down into the water. There was no longer a lane for the metals. It had to be made by hewing and blasting galleries, and swinging the track from one bank to the other to gain the slightest foothold. The most notable crossings are the Verrugas bridge and the Infernillo bridge. At the Infernillo, the main stream breaks through two walls of solid rock, 1500 feet high, and the train crosses from wall to wall, out of a tunnel on one side into a tunnel on the other.

The Verrugas bridge, that lies at an altitude of 5,839 feet, was the scene of a strange disaster. Large gangs of workmen were crowded upon the task, because, until the bridge was erected, material for continuing the line could not be carried over the gorge. But while the men were busy building up a huge masonry pier in the bed of the stream, a strange and terrible disease broke out. It was a disease peculiar to the neighbourhood of the Verrugas stream, and it became notorious as the Verrugas fever. It was deadly, and there was no cure for it; in one cutting alone seven hundred men died from the mysterious malady. It struck down natives and white men alike. Men contracted the fever, died, and were buried in a few hours after reaching the site; and it is said that one man perished after merely crossing the fatal bridge. Most of the workmen fled, and the mysterious pestilence threatened to stop the whole enterprise. Extraordinarily high wages were offered to men to come up the Andes and risk their lives, and a band of adventurers were at last found willing to face an uncanny death on the mountain heights. Owing chiefly to their exertions the gorge was at last spanned.

Meiggs himself was more fortunate than many of his workmen, for though he haunted the valley of death night and day, the fever did not attack him. The terrible experience, however, broke him up, and when the bridge was completed he was changed into an old, enfeebled man. Yet he held resolutely to his great scheme. Having crossed the deadly gorge, he entered the wildest region of the Andes. The mountains rose up like walls, and the ravines grew deeper and more difficult to bridge. Moreover, the slopes were continually swept by landslides. One rockslide and cloudburst destroyed, some time afterwards, the Verrugas bridge that had cost so many lives to build. Meiggs, however, fought his way upward. Half a million pounds of explosives were used every month in blasting out curves and zigzags in the cliff-side and in tunnelling through the rock.

The most remarkable feature of Meiggs's achievement was his V-switch. He had run his track forty-seven miles into the mountains, and reached a height of a mile above sea-level, when the ledge on which he was laying his track came to an end. Further advance seemed impossible. The task of cutting a tunnel was too heavy, difficult, and expensive. Below, the cliff fell sheer; above, it towered to an appalling height. So Meiggs was in a sorry position. A few feet above him, however, there was another ledge running along the face of the cliff. The daring engineer resolved to lift his trains from the lower to the higher ledge. At the end of the track he erected a turntable, from which two short lines ran in the form of a widely opened V. The main line cut across the top of the V, forming a triangle

THE V-SWITCH, DEVISED BY HENRY MEIGGS, SHOWING A LOCOMOTIVE ON THE TURN-TABLE

This is how the V-switch works. The engine pulls the train up the lower line, on to the section crossing the top of the V. The engine is uncoupled and runs down one leg of the V on to the turn-table. This is then swung round until the engine faces the other arm of the V, up which it steams until it gains the main line. It is now at the rear of the train instead of at the front. It is coupled up, and it then pushes the train backwards over the switch connected with the upper level. There are twenty-two of these V-switches on the great mountain

line. In one place the switch is set in a very dangerous situation. The line climbs up a ledge blasted out of the flank of the peak, and every time the train lurches a traveller is apt to know what fear is.

What would happen if a train ran away at one of the switches? There are apparently two courses open to it—one through the air to the bottom of the gorge, and another down the track to a smash up against the dead-stop. Meiggs, however, foresaw all this, and at the end of the line from every V-switch he erected a great bank of earth. Some years ago a train ran away while passing from the upper to the lower level. It was stopped by the solid embankment, in a damaged condition, but nobody was hurt. Meiggs saved thousands of pounds by the invention of his switch. He worked with feverish energy; and in spite of the extraordinary difficulties he encountered he kept the line going forward. In six years it stretched nearly ninety miles into the Andes, climbing to a height of 12,216 feet. But the strain of the marvellous enterprise told on the American engineer. His strong constitution had been weakened by the horrors and anxieties of Verrugas bridge; and as he went on working and planning at the head of his line, the thin, light atmosphere of the great heights wore him down. He perished in 1877, as the line reached Chicla.

THE ILL-OMENED VERRUGAS VIADUCT ON THE OROYA RAILWAY, PERU

At his death, two-thirds of the scheme for crossing the Andes had been carried out and the worst difficulties surmounted. But for fourteen years the line stayed at the spot where Meiggs had fallen. The Peruvian Corporation of London, however, took over the railway, and engaged another Philadelphian engineer, William Thorndike, to complete the section. Thorndike carried the track another 3450 feet above the sea, and then came to the grand obstacle. Above him was the summit of the mountain, over which it was impossible to lift the metals. A tunnel 3855 feet in length had to be driven through a rocky peak in circumstances of strange difficulty. The altitude was so great that all the workmen suffered from mountain sickness; the strongest man could only work for a few hours at a stretch in the rarefied atmosphere. An effort that a man would not notice on the tropical plain miles below made the blood ooze through the lips and fingers. Yet the rock had to be drilled and blasted and excavated, and the heavy soil had to be removed.

Thorndike was an organiser of genius, and by husbanding the strength of his men he drove the metal track at a record speed through the mountain summit. His tunnel is the crown of the greatest of all railway enterprises. In the centre of it one stands on the Great Divide of South America, nearly 16,000 feet above the sea. Upset a bucket of water there, and part of the liquid will flow towards the Atlantic Ocean, while the other part will run towards the Pacific. From Galera tunnel the line sinks for 3500 feet to Oroya, which is 31½ miles distant. This last part of the track was made very quickly, as there were no more amazing obstacles in the way.

Altogether, the highest railway in the world cost £8,500,000—more than the total cost of the St. Gothard Railway with its famous tunnels through the Alps and 172 miles of track. Some day, perhaps, means will be found of carrying out the whole of Meiggs's scheme. From Oroya the metals will be dropped across the plateau to the bank of the Amazon, where a service of steamers will connect Peru with Europe. It is difficult to say whether the opening of the Panama Canal will hasten or retard the completion of this mighty project. If the Canal dues remain high, it may be found worth while to drive the Oroya line, now known as the Central Railway of Peru, to the great waterway of South America. In all probability the Amazon region will be opened up to industry and commerce by the present generation; and when it becomes an

important centre of production the railway may climb down to it.

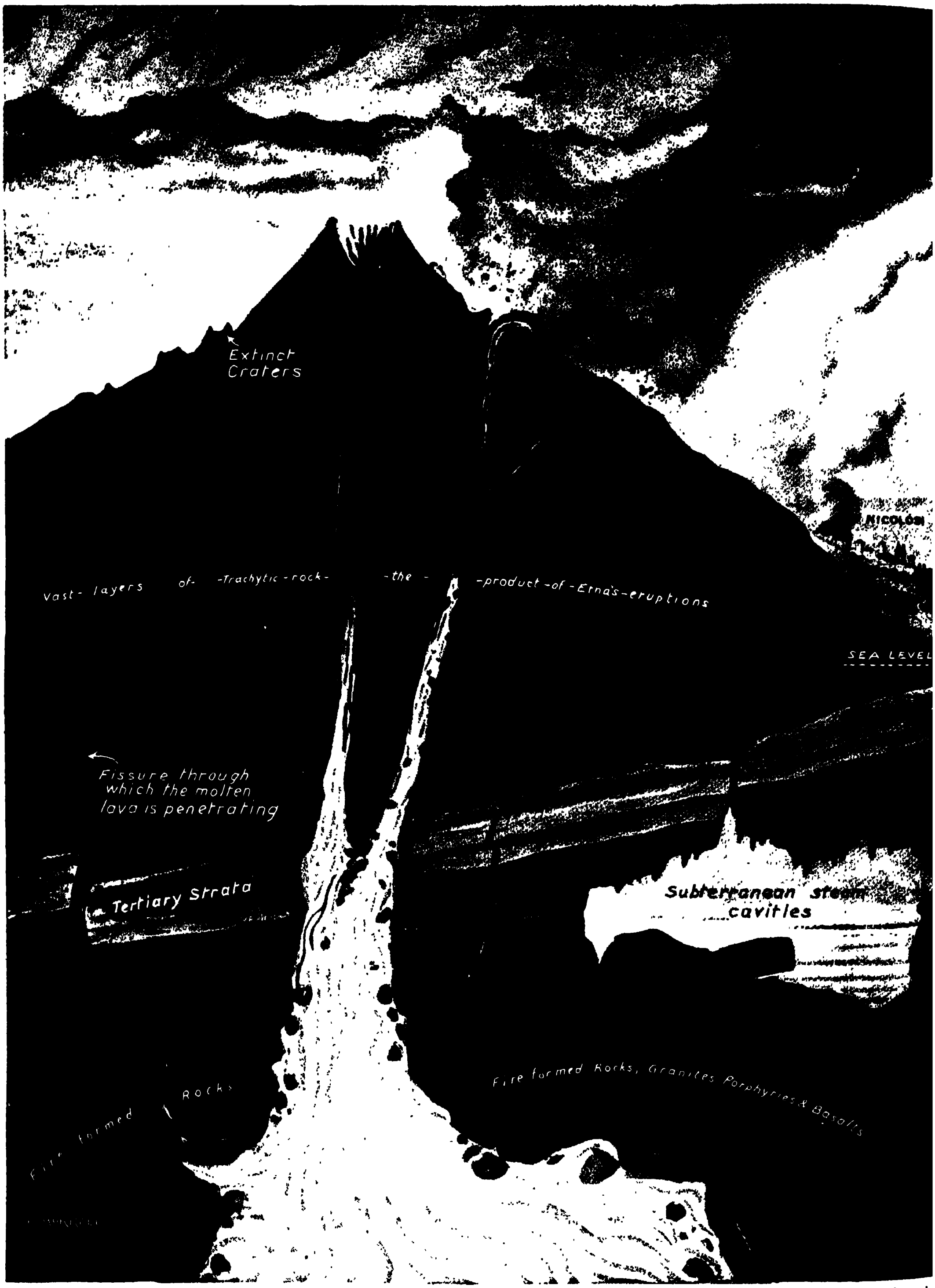
At present, however, the Oroya track is famous for its hundred-mile coast from Galera to Callao. It is the only road in the world down which a man on wheels can travel for more than one hundred miles by his own momentum, at practically any pace to which recklessness may urge him. He starts with the eternal snows around him and the unspeakable trouble of mountain sickness inside him; he finishes among humming-birds and palms in the ecstasy of an exultation beyond expression. The adventure is undertaken on a small, light, low, railway truck, with two low-backed seats, holding each two persons. After a gentle push and a travel of a few yards, the hand-car acquires a momentum that would end in death and destruction were it not for the brakes by which the driver can in a few seconds pull up a few yards away from any point on the journey. But the driver is only human, and in his delight in the entrancing rapidity of motion he sends the car racing down the mountain. There are, of course, dangers in this headlong rush. The curves are very sharp, and rocks and stones often fall on to the track.

The dogs of the Andes have an objection to the coasting-car, and sometimes they carry their objections too far, and there is a collision. The precipices, the pitch-dark tunnels, and the narrow, dizzying bridges try the nerves of the novice until he catches the passion for rapid motion and urges the driver to a higher speed.

Some miles to the south of the Oroya there is another mountain railway, 332 miles long, that soars to that strange inland sea Lake Titicaca, lying among high Andes, some 14,660 feet above the Pacific Ocean. The mountains, however, are wider apart, and there are none of the fearful ravines against which Meiggs had to fight. The line goes upward in broad, sweeping curves; there are no zigzag climbs and V-switches that occur so frequently on the other track. The constructing engineer was at first much alarmed by the sand-armies he met in the higher altitudes. The sand forms strange cones, from ten to twenty feet high. From the distance they look like a vast ar, y of men marching in regular lines and grimed with the desert dust. Under the influence of the wind they move against the railway in a steady, rhythmic manner. When the line was being built it was thought that elaborate precautions would have to be taken to keep the track clear from the hosts of the sand. Happily, it was found that trains

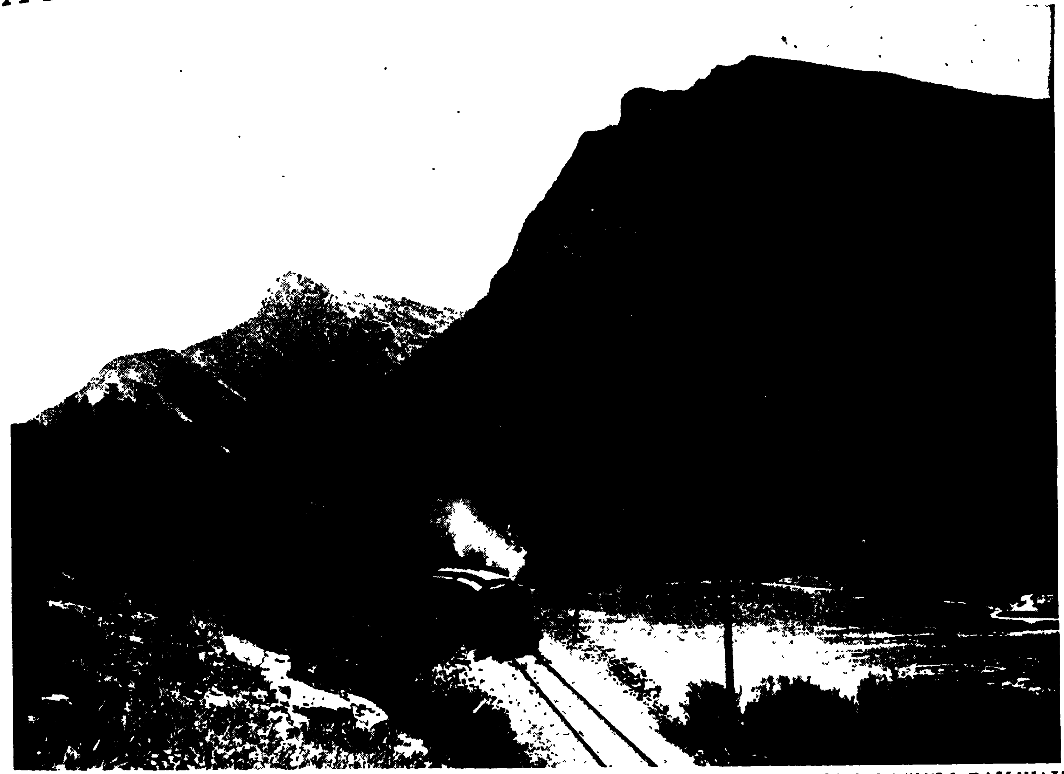
THE ENTRANCE AND EXIT OF A HORSESHOE CURVE WITHIN THE PERUVIAN ANDES

HOW EARTH'S CENTRAL FIRES BURST OUT



A section of the historic volcano Etna—supposed in classic times to be the entrance to Pluto's kingdom—showing how molten lava, formed by the liquefaction of the lowest rocks, is projected upwards through fissures in the superincumbent strata until it escapes through the main crater or through subsidiary cones, and so keeps adding to and raising the mountain as it cools on the surface

A MOUNTAIN PATH—PRAIRIE TO PACIFIC



THE ROCKIES, A BARRIER OVERCOME BY THE ENGINEERS OF THE CANADIAN PACIFIC RAILWAY

THE DESCENT OF THE CANADIAN PACIFIC RAILWAY NEAR MOUNT SELKIRK, IN THE ROCKIES

could with little difficulty plough their way through the sand-cones. After the sand is passed, the line runs through a region of broken rock in which no sign of life can be seen. At the edge of this upland wilderness is the great fresh-water lake which the iron road now links to the Pacific Ocean.

Meiggs's idea of a South American Transcontinental railway has recently been carried out in Chili and the Argentine. By lifting the metals over the Andes, Buenos Ayres, on the Atlantic, and Valparaiso, on the Pacific coast, have been connected. The line rises about two miles above sea-level, and it took very long to build. Floods, avalanches, and landslides made the work very difficult. The wildest and most beautiful part of the track is the Yellow Gorge. Meiggs's V-switch is used at the beginning, but the engine has to keep climbing such steep slopes that even the switches at last become useless. As a matter of fact, the ordinary railway line itself became impossible; and the train now grips its way over the Andes by means of a cog-wheel fitting in the rack-rail. Instead of making long, gradual sweeps, the line goes up in the form of a series of steps. There are short level sections over which the engine runs in the ordinary way, and in between these are the sharp inclines up or down which the train climbs by means of a cog-wheel.

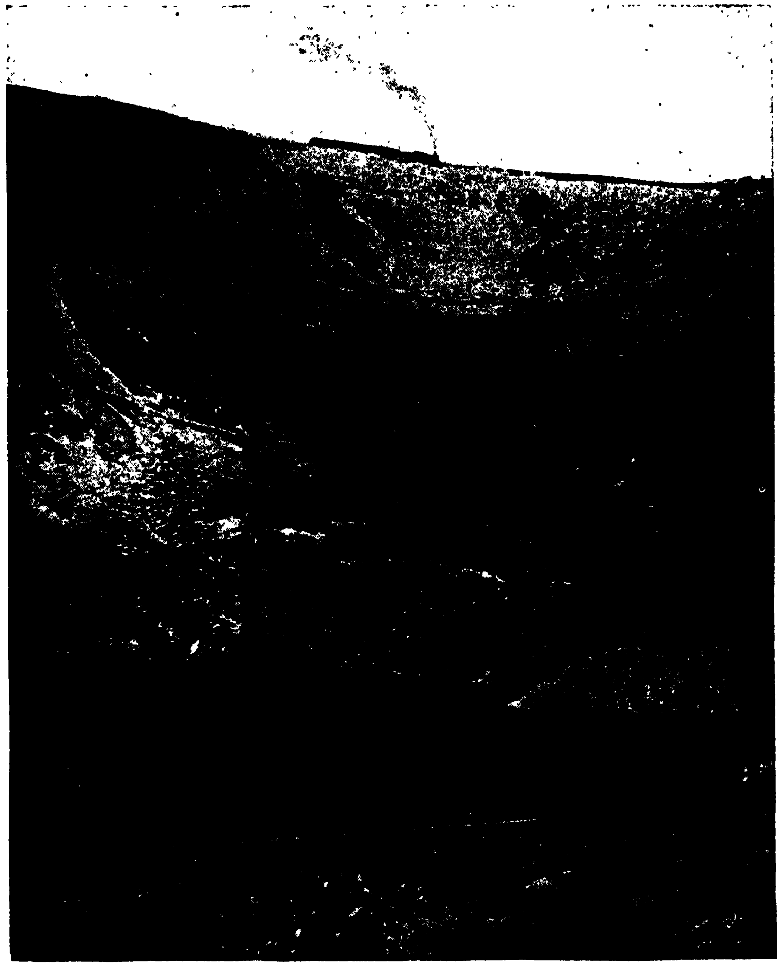
COASTING FOR 100 MILES FROM SNOWCLAD MOUNTAIN TO TROPICAL VALLEY ON THE OROYA RAILWAY

In travelling through the gorge one beholds the most sublime mountain scenery. The snow-crowned top of Aconcagua rises 23,500 feet in the blue sky, Tupungato towers 21,451 feet, and Toloso 19,000 feet, and around them are many other white and majestic peaks. The Transandine is one of the greatest scenic railways in the world. It has opened up what was previously an inaccessible centre of sight-seeing, and its station at Inca has become a popular starting-place for the climbers of the Cordilleras. At the highest point on the line a train is two miles above the oceans it connects. The most difficult piece of engineering on this famous mountain railway was the tunnel through the summit linking the Argentine section with the Chilian. Nearly two miles of rock and earth had to be drilled, blasted, and excavated; and the work was so arduous that the two railways at last gave it up, and called to their aid the famous English firm of tunnel-builders, Messrs. C. H. Walker and Company. Hospitals had to be built for the treatment of the crowds of workmen who became stricken with

mountain sickness, and there were many cases of pneumonia caused by the Arctic weather in the high altitudes of the Andes. In winter the cold was intense, and the furious winds drove the ice and snow with such force that they cut like a knife.

It was at first thought that, for six months in the year, the upper levels of the line would be blocked. But the engineers now fight the mountain snow that sweeps down on the wings of a hurricane and buries the railway to a depth of thirty feet or more. Usually a powerful rotary plough can eat its way through the snow, and clear the track. Unfortunately, the whirlwinds bring large masses of rock from the crests, and tumble these in the railway cuttings, and then cover them with snow. When a rotary plough, running at full speed, strikes against one of the huge boulders, the auger-like mechanism smashes to pieces, and the whole costly, ingenious apparatus becomes useless. But a new machine has now been devised for removing the snow and avoiding the boulders. It is a push-plough of a wedge-shaped pattern. It cuts through the deep snowdrifts rapidly and easily, but when it meets a boulder its nose glides over the hidden obstacle, and does not suffer any damage. The snow-plough train carries a gang of snow-clearers, and these jump out when a piece of rock is reached, and lift it out of the way or blow it up with dynamite.

A still more wonderful mountain railway across the Andes is that running from the seaport of Arica, on the Pacific coast, to La Paz, the capital of Bolivia. When fully completed, this line will be the supreme achievement in the land of railway wonders, for it lies for the greater part of its length of 292 miles at a height of twelve thousand to fourteen thousand feet. No tunnel carries it over the Andes. It rises abruptly from the coast, and then goes right over the crest of one of the greatest mountain ranges in the world. This is done by means of the toothed rail or rack system, which has to be employed over forty miles of the track. In many places the builders have had to blast the trail out of the rock by dynamite in order to advance. Then a mighty gorge has intervened, over which long bridges have had to be flung in a single span. All the work has to be carried out with extraordinary care, for the material is subjected to a continual and heavy series of strains.



A TRAIN ON THE GREAT DIVIDE OF THE ROCKIES, HAVING RISEN FROM THE TRACK BELOW AT A GRADIENT OF ONE IN 25

From "The Railway Conquest of the World," by Mr. F. A. Talbot

For instance, one of the single-span bridges is over 150 feet in width. Every night and day this huge structure is first pulled out and then crushed up by the

mightiest of terrestrial forces. At daytime the thermometer will stand at 100 degrees; at nightfall it will often drop to below zero. A tremendous difference of 113 degrees in the course of a few hours is by no means uncommon. When it is remembered that the average fluctuation of temperature in our country is only 17 degrees, it will be seen that the daily contraction and expansion of metal on the high mountain railways of South America are enormous. First the heat wrenches at every bit of iron and steel; then the freezing cold at nightfall distorts it in another direction. These great changes in temperature also affect the rock and rubble around the line, and bring about the terrible landslides which are the worst danger to the mountain railways of South America. Meiggs's track is especially subject to avalanches of boulders and débris. The entire structure of Verrugas bridge was destroyed by a terrible landslide. The central pier was knocked away, leaving the tangled, twisted metal hanging down the ravine.

In Northern America, the State of Colorado offered some remarkable difficulties to railway-builders. It contains one hundred and twenty mountains that jut more than 13,000 feet into the clouds, and thirty-five of them rise to an altitude of more than 14,000 feet. Between the thronging peaks there are canyons, the walls of which are half a mile and more in height; and populous and busy towns, like Leadville, flourish at an altitude of nearly two miles above the sea, and prosperous mining-camps at a height of 13,000 feet. It was the discovery of the immense mineral wealth buried in this wildly picturesque part of the Rocky Mountains that tempted the railway-builde to bring his metals over the gorges and ove the Great Divide.

There was a gold rush in 1859, followe by a silver strike, and Leadville sprang u in the heart of the mountain range. Ever ounce of material had to be carried to an from the outside world by waggon, mule pack, or on human shoulders, through dee gulches and over broken mountain trails There was a cry for a railway, but it wa hard to discover a man with the mone and the pluck to finance the strang enterprise. It wa thirty years befor the entire schem was carried out. A beginning wa made by layin a line through th Royal Gorge, on of the natural won ders of America The defile is abou half a mile deep and in places th walls rise so sheer ly that only a bir can find a way up At the bottom is a river, which, i times of flood, lap the base of th mountain walls o either side. A the foot of on cliff there is a narrow shelf which is only ex posed when th water is at it normal level.

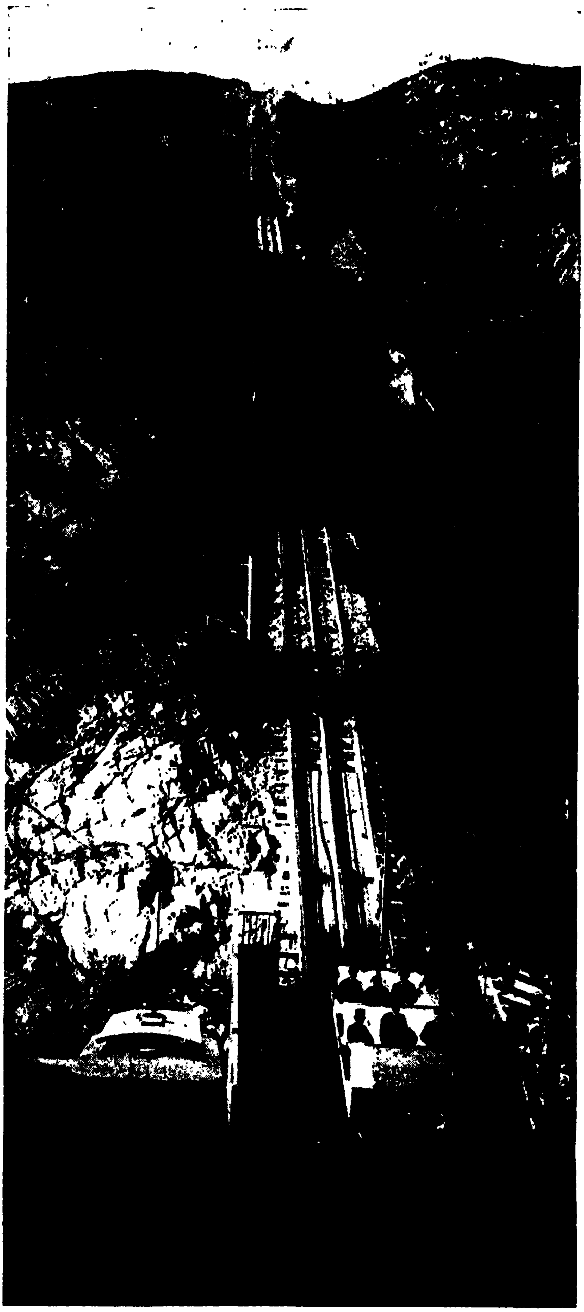
A SPIRAL TUNNEL AMONG THE ROCKIES

The engineer Mr. A. A. Robin son, resolved t use this shelf. H kept the flood water away by a wall of masonry, an then ran the rails along the shelf to th eastern portal of the ravine. But here th ledge disappears, and the two sides of th canyon, towering up 3000 feet, com close together, leaving a space of ten yard through which the water thunders with th speed and strength of a cataract. It wa absolutely impossible to build a pier in th waterway, and rest a bridge upon it. I was also impossible to blast a track out o the side of the canyon, and the enginee could not tunnel through the rock, fo

his company had scarcely sufficient funds to make even a surface line in hand.

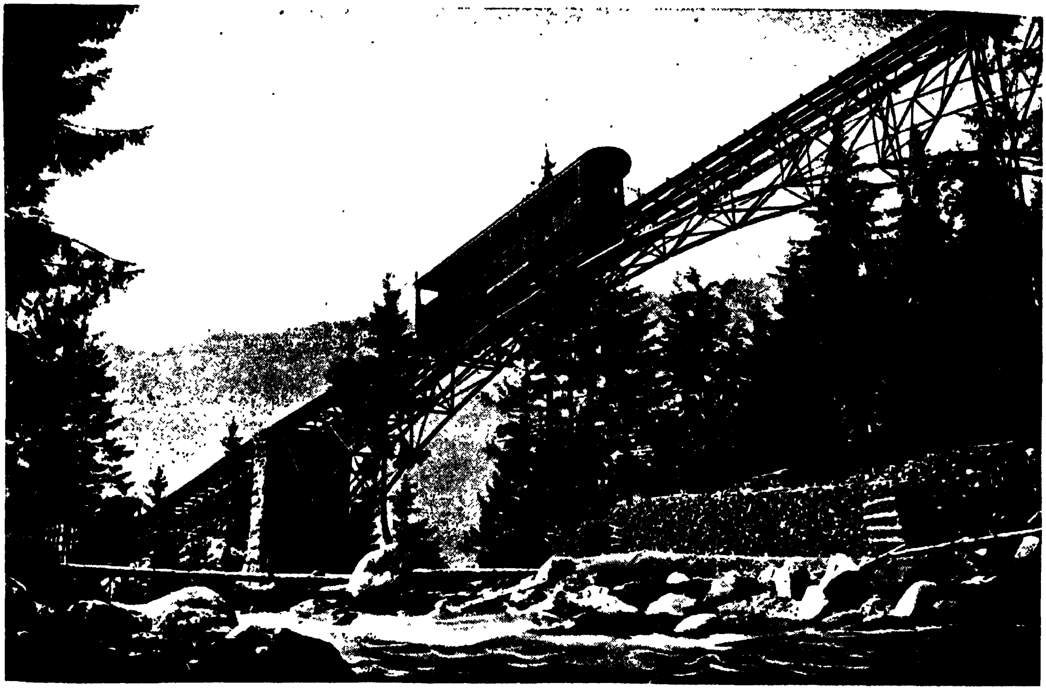
Tunnelling was bankruptcy. For days Mr. Robinson wandered up and down the gorge, trying to find some way of carrying his line forward. At last he hit upon a new thing in engineering—a hanging bridge. He hewed a ledge, from a foot to a foot and a half wide, above the site, and from this narrow foothold he and his men worked. Heavy iron girders were thrown across the gorge, and their ends were anchored to the solid rock. The men were lowered by ropes, and they plied their tools while swinging in mid air, or clinging to some hazardous foothold. When the huge, strange iron structure had been fastened to the cliff, the bridge carrying the railway track was suspended from it, and carried over the terrible ravine.

The railway crosses five great canyons before it traverses the mountains that form the backbone of the North American continent. Level sections of track are practically unknown. On the one side it is a continual up-hill pull, that needs two huge engines to get a train along. On the other slope it is a long down-hill run with steam shut off—a switchback upon a gigantic scale. At Fremont Pass the track is 11,330 feet above the sea, and another 200 feet is reached on a branch road to Ibex. The most impressive scene on the line is that on either side of the Toltec tunnel. After skirting a mountain spur, the train swings into Phantom Curve, a strange region covered with weathered pillars, carved into weird shapes by rain and frost and wind. Passing through the tunnel, the train emerges on the brink of a precipice that drops plumb a quarter of a mile into the valley. The dizzying gulf has been spanned by a balcony of stonework, built by men working on an unsteady platform slung out from the derricks.



A STEEP ASCENT OF THE CABLE RAILWAY AT MOUNT LOWE, SOUTH CALIFORNIA

A little carelessness in footing, and the masons fell on the crags that rose a quarter of a mile beneath them. Right opposite is another mountain ledge which the train now reaches in an instant after emerging from the tunnel. On another part of this line the train has to face a mountain and climb over it, for the engineers found no detour was possible. The line first skirts the base of the mountain and makes a sharp curve, and then runs backwards, the metals being parallel with those shining a few yards below. In terrace after terrace the track goes upwards, through cuttings and over embank-



THE CABLE RAILWAY AT GEISSBACH, IN THE BERNESE OBERLAND

ments and high trestles, until the summit of the range is reached.

Recently the Silver King of Denver, in Colorado, Mr. David H. M. Moffatt, came to the conclusion that his town ought to be directly linked with the Pacific coast. He was not contented with the railway across the Rockies that Robinson had begun, for it was over a hundred miles away from Denver. The Silver King had plenty of money to spend, and he intended to send a new metal track over the Rockies in a straight line towards Salt Lake City. His engineers were in the happy position of being able to spare no expense in making the new line remarkable for solidity and strength. No timber-trestling across clefts on the hillside was allowed. The track was kept on an easy gradient; and whenever the shoulder of a mountain got in the way, a tunnel was run through it. In one place there are thirty tunnels in thirteen miles; and their constant recurrence provoked some passengers to ask why Moffatt did not tunnel the range, as they do in the Alps, and have done with it. At the top, a tunnel 2½ miles long passes over the Great Divide at a height of 9930 feet above the sea. But this tunnel was too long in drilling for the Silver King of Denver. He wanted to get to the Pacific in a hurry. So he told his engineers to lift the line clean above the Rockies. This meant carrying the track over Rollins Pass, 11,600 feet above the level of the sea, through a world of eternal snow. The railway-builders were equal to the task, and by means of tremendous curves and wide upward loops they got a train over the Great Divide.

Then winter came, and with it terrific blizzards that buried the metals under hills of whirled snow. So the biggest and most powerful rotary snow-plough was ordered by Moffatt. With this huge machine the snow-gangs fought the winter snow from morning to night, all through the severe weather. At times their battle against the tremendous forces of Nature on the high mountains seemed absolutely hopeless. They had the strange, weakening mountain sickness to fight against, as well as the perishing cold; and for weeks the shrieking, blinding hurricanes brought the snow along as fast as the plough removed it. But the men held to their work, and kept the narrow channel of communication clear, while, far below, the Silver King carried on his game of high finance. At the present time the tunnel takes both in summer and winter the bulk of the traffic, but the adventurous line right over the Rockies has not been entirely abandoned. It attracts many trainloads of sightseers; for at the tremendous altitude of 11,600 feet

there is a magnificent panorama of snow-fields and glaciers, and sombre, majestic mountain peaks.

Yet this is not the highest mountain railway in the Rockies. Pike's Peak, in Colorado, that rises 14,147 feet above the sea, and commands a view of 100 miles radius, is so difficult of ascent that General Pike, the discoverer, failed to reach the summit. His opinion was that no human being could win to its pinnacle. Now, however, a full-gauge railway takes travellers to the topmost crag. The line is only 8½ miles long, and is a combination of the ordinary rail and the cog-wheel system. Thousands of trippers go up the peak every year. The great mountain has become a pleasure resort, like Snowdon and the Jungfrau.

Little, pleasure mountain railways are now becoming very common. None of them has about it the romance and picturesqueness of the great traffic lines that climb the Andes and the Rockies. The early engineers were men of heroic mould, who faced Nature in her wildest, sternest mood, with dreams of empire in their brains. They battled with the mountains with the high ambition of enabling nations, cramped and limited by the great heights, to expand from ocean to ocean. In both North and South America the great mountain railways were designed to link together the Atlantic and Pacific Oceans, and avoid the long and hazardous voyages round Cape Horn. They were grand practical achievements, in which was displayed in a noble and magnificent manner the new power that man had recently won over the most tremendous of natural obstacles.

For a million years the great mountain ranges had stayed the path of mankind. The forests had been conquered by the axe, the seas had been overcome by ships, and even the icy wastes of the Arctic regions had been traversed and largely explored. But the mighty barriers of rock still remained, and exercised their ancient dividing and restricting influences on the commerce and society of men. It was not until daring and ingenious engineers like Meiggs and Robinson found a way of lifting trains over the high mountain ranges that the great natural barriers of the earth were overcome.

In India there are three or four famous mountain railways, some built for military purposes; others, like the Darjeelin line to the tea plantations on the lower slopes of the Himalayas, constructed for commercial purposes. They all greatly help to weld our great Oriental Empire into a single organised entity, bringing the peoples of the plains and the heights together for the first time in history.

AN ELECTRIC TRAIN ON THE BERNINA RAILWAY CLEARING ITS TRACK WITH A SNOW-PLOUGH

The little, pleasure mountain railways that abound in Switzerland naturally lack the historical romance of the mighty lines that travel over the heights of America and India. The important Swiss railways go under the Alps instead of over them. They are marvels of tunnel-building rather than of mountain-climbing, though they sometimes rise to a considerable height before burrowing under the snow-crowned peaks of Central Europe. Yet the little excursion tracks that clamber up the sides of the Rigi, Pilatus, and the Jungfrau are wonderful examples of the extraordinary power of the modern engineer.

BY RACK AND PINION UP TO THE RIGI

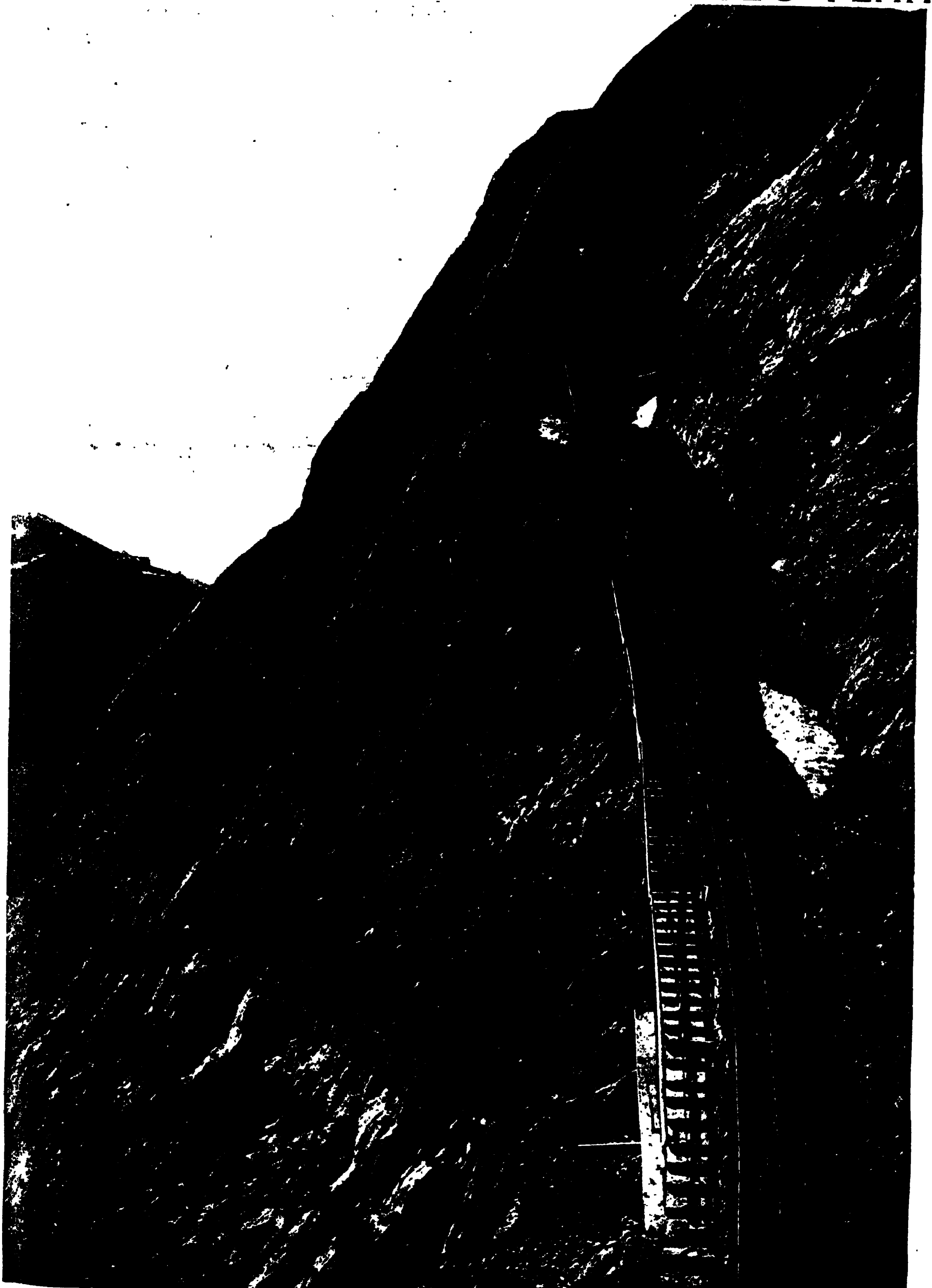
There are three methods of lifting a passenger train to a mountain top. Where it is possible to make long, sweeping curves that ascend a mountain side very gradually, the ordinary railway line may be used. In this case, the train climbs up simply by the adhesion of the wheels to the metals. The adhesion system is practical so long as the line does not rise more than six feet in every hundred feet of the track. When the slope is steeper than this, the mere adhesion of the driving-wheels of an engine is insufficient to move more than the locomotive's own weight. So the second method must be employed.

THE RAILWAY UP TO THE ROCHERS DE NAYE

Two or more toothed rails are laid close together, and usually the teeth are not set opposite to each other. So the cogs on the engine-pinions do not jump from one set of teeth to another, but keep a continual grip of the rack. The result is that the running is free from jar or vibration. In descents as well as in ascents, the cogs on the engine-pinions grip the teeth of the rack rails. There is no coasting, as in the descents on the great adhesion lines. The train claws its way down as carefully and as slowly as it claws its way up. In the third method, such as is used on the Vesuvius railway, the train is practically a lift, which is drawn up and let down by means of a strong and well-tested cable. Remarkably steep heights can be climbed in this manner, but from an engineering point of view there is very little interest in a cable railway. As we have said, it is merely a lift masquerading as a train.

Some time ago it was proposed to build a railway to the summit of the Jungfrau, the most beautiful of Swiss mountains, and work it by means of a cable. There was also a scheme for using compressed air; and steam power was likewise thought of. None of these projects, however, was carried out. At the present time, an attempt is being made to propel a train to the summit—13,671 feet above the sea—by means of two mountain streams flowing through the deep valleys at the foot of the famous height. If all goes well, the loveliest of the Alps will, in the course of a year or so, be conquered by the power of her torrents. They are already harnessed to powerful water-wheels that generate all the electricity that is required to work and light the line. The electric trains now climb up to the Jungfraujoch Station, opened in July, 1912, a little below the summit. It is 11,451 feet above the sea, and the engineers are still tunnelling upwards through the rock to the last station. When this is reached, an electric lift will

NEARING THE SUMMIT OF PILATE'S PEAK



THE SHEER ASCENT OF THE RACK-AND-PINION RAILWAY UP MOUNT PILATUS
The photographs on these pages are by permission of Wehrli, The Peruvian Corporation, and the Canadian Pacific Railway.

raise the trainloads of pleasure pilgrims to the topmost crag of the great Alp, from which the view stretches to the Black Forest, in Germany.

When finished, the Jungfrau railway will be one of the greatest triumphs of engineering. What is perhaps more noteworthy is the fact that it will also be an artistic success. For it has been so designed as not to injure the sublime beauty of the mountain. The track is carried through long tunnels, lighted with electric lamps, and the station is a great cavern in the mountain side, with an opening in the rock through which the glorious scenes around can be studied. Never before, in Europe, has a tunnel been constructed at such an altitude, and certainly not one in which a train climbs up a gradient of one foot in every four feet. And it is doubtful if work has ever been accomplished under such conditions of climate as prevail in this region of eternal snow.

The engineers were unable to profit by the experience acquired in the construction of other mountain railways. They had to invent and construct special devices and appliances, to enable them to proceed with their work. The electric locomotives travel at a speed of $5\frac{1}{4}$ miles an hour. Neither in ascending nor in descending can this pace be exceeded. For an automatic brake comes into play, and stops the train. The sudden failure of the electric current is also provided against. The engine can descend, if necessary, without it, generating by its own weight the electricity necessary to work the brakes. On the front axle of the locomotive is a strong gripper, which grasps the rack and prevents the engine from rising. Each locomotive has two carriages, with seating-room for eighty passengers.

At present the chief advantage of this little pleasure railway is that holiday-makers are able to play at winter sports amid glaciers and snowfields at the height of summer. After October the heavy falls of snow prevent the railway from being worked. During the winter, the engineers and their staff are cut off from the world, and provisioned till the spring. One hundred and thirty tons of material are carried up to them in autumn. Sometimes the telephone wires break down; but so long as nothing goes wrong with the two copper wires that supply the electric power, the little community does not suffer any great inconvenience.

THE ROCK-HEWN STATION OF THE EIGERWAND ON THE JUNGFRAU RAILWAY

THE MEETING ON THE RIGI OF THE LINES FROM VITSNAU, AND FROM ARTH

THE WINDINGS OF THE ST. GOTHARD RAILWAY—SEEN AT THREE DIFFERENT LEVELS

CUTTING OFF THE LEAVES FROM BEETROOTS ON A FRENCH FARM

CUTTING DOWN FULLY GROWN SUGAR CANES ON A JAMAICAN PLANTATION

THE SUGAR INDUSTRIES

How Napoleon Intervened in British Trade and Established a New Manufacture

BATTLE BETWEEN THE CANE AND THE BEET

SINCE the great fall in the price of sugar in 1884 the production of this important article of food has led to a fierce, incessant struggle between planters in the tropics and farmers in temperate regions. The sugar cane has had to battle against the beetroot. Behind the beetroot was the science of France and Germany, with a century of experiment, research, and invention. By scientific methods a beetroot of insignificant sugar-value has been developed into a plant with a remarkably high percentage of sucrose: and in recent years the increase in the manufacture of beet sugar has been enormous. It has seemed as though the advantages of cheap capital and improved agricultural methods, supplemented by State bounties and the operations of a vast and powerful trust system, would enable the farmers of the temperate zone to defeat the tropical planter, and supplant him in the sugar markets of the world.

In India about two and a half million acres of land are under cane cultivation. From time immemorial down to quite recent years it was the greatest sugar-producing country in the world. Now, however, its export is insignificant, and it is becoming an important market for Austrian and German beet sugar. As a matter of fact, an immense amount of native cane produce is still made, but it is insufficient for the needs of the people. Being mainly rice-eaters, they have an intense hunger for sugar, which has a food-value equal to that of lean meat. But as the peasantry keep to primitive methods of agriculture and manufacture, they do not grow half as much sugar as their available area of cultivation would yield on the modern system. In several other parts of our tropical dominions that used to provide the greater part of Europe with cane sugar there has been a period of defeat and disaster at the hands of the beet-growers, and regions admirably adapted for the growth of canes have had to be planted with other crops.

Widespread misery has been caused by this revolution in industry. Yet it is not certain that the present victory of the beet-sugar makers on the mainland of Europe is final. Under the stress of competition the tropical planter is rapidly improving his agriculture and his machinery. It is now clear that when he possesses suitable and accessible lands, a good supply of labour, and an up-to-date factory system he has little to fear from the beet-farmer. He can deliver his sugar to the British and American markets at a price that enables him to hold his own against the producers in the temperate zone, provided the conditions of competition be not rendered too unequal by State subsidies and restrictions and other artificial advantages that have nothing to do with the actual cost of production.

In Java, for instance, cane sugar is produced at less than a halfpenny per pound on land of only average fertility. When raw sugar fetches three-farthings a pound the plantation farmers, it is said, make a profit of 40 per cent. Much more of the soil of this great tropical island would at once be laid out in sugar plantations if the Dutch Government had not limited the area, and forbidden the refining of cane sugar in Holland. It is these restrictions that protect the beet-growers of Holland from open competition with their colonial cane-planters; and there can be no doubt which way the struggle would end if it were waged on equal terms.

The restrictions and impositions to which Java sugar is subjected make it patent that well-managed tropical plantations are

again very formidable rivals to the best beet-fields of the temperate region. The Javanese owe their remarkable position in the affair to the excellent technical direction in agriculture which they have received for many years from the Dutch. If only the peasantry of India were trained in modern methods of culture, and assisted by British managers and capitalists and native business men, they could supply all the wants of their countrymen, and feed a great number of sugar factories with millions of tons of sugar for the Chinese and British markets.

The sugar cane is a grass. It is the giant of its family, attaining at times a height of fifteen feet. Allied to it are the bamboo, the Chinese cane, the maize plant, various cereals, and many foreign grasses. All of these contain sugar in greater or less quantity. The sugar cane is found in a wild state in some South Sea Islands, and it may have been introduced into India during the obscure wanderings of races in the prehistoric age. However this may be, the Indians were cultivating sugar cane at a time when the Greeks and Romans had only honey as a sweetening food. Fifteen hundred years ago the cultivation of the cane was still confined to Bengal. What little came into Europe was very costly, and was used only as a medicine.

PLANTING CANES ON AN IRRIGATED PLAIN OF PERU

Brought into Southern Europe by the Moors, the cane was first grown in Spain, and afterwards planted by the Portuguese in the Madeira and Canary Islands, and from the fifteenth to the seventeenth century Europe derived most of her sugar from these islands. On the discovery of the New World, the Portuguese and the Spaniards carried their valuable canes to their new dominions. In the meantime, the modern method of refining sugar, invented by a Venetian, was improved by Englishmen, and in 1585 London became the centre of the European sugar trade. This position our country still held in the days when Napoleon tried to block the Continent to all our commerce.

One of the results of the blockade was that sugar became scarce and expensive on the mainland of Europe. With a view rather to hurting our country than to benefiting his subjects and allies, Napoleon, with characteristic attention to small details, started to investigate the possible domestic sources of sugar. The white beetroot had already attracted the notice of some German chemists; and though the sugar-content was naturally small, English sugar was so dear that it paid to use the beets as long as British merchandise was excluded from the Continent. For many years the beet could not be grown at a profit in open competition with the canes of the tropics. But the impetus that Napoleon gave to the cultivation of the temperate plant produced at last some surprising results.

In 1878, a French seedsman, Vilmorin, succeeded in creating, by a long and careful process of selection, a beet possessing 14 per cent. of sugar. France then became the home of an important new industry. But the Germans improved upon Vilmorin's discovery. By patient, plodding, methodical research they defeated the French growers, and then by means of bounties so increased their output that they obtained the practical control of the sugar industries. Thus, indirectly, and long after his death, the blow that Napoleon aimed at our sugar trade struck us. The Germans and Austrians took full advantage of their enormous production of raw beetroot sugar, and the number and the importance of our sugar refineries grew less and less.

But though the Germans and Austrians are now supreme in all the processes of sugar production, our country still manages to

exercise a large influence in the matter. She is now the greatest importer of sugar, instead of the greatest exporter. But, far from consuming all that she imports, she turns an immense quantity of it into new articles of international commerce, and by means of sweetstuffs, jams, and other sugary conserves she profits greatly from the bounties or taxes by means of which the Continental nations support their sugar industries.

Perhaps in the long run the foreign policy of subsidising the export of sugar and taxing the home consumption of it might end in a general disaster to British sugar interests. But, besides the possibility of our cultivating the beet in our islands, there are the sugar-cane plantations of the tropics ready again to expand in productive power if any attempt to heighten the cost of beet sugar. Indeed, it is not unlikely that the sugar cane will, even in the present circumstances, prove a formidable rival to the beet. It can further be improved in quality by the scientific selection and propagation of the finest canes. What has been done with regard to the beet can surely be performed with reference to the cane.

HARVESTING THE SUGAR CANE ON A PLANTATION IN LOUISIANA, UNITED STATES.

When the beet was first studied it yielded only one and a half parts of sugar for every hundred parts of the root. It now does not pay to grow beet with less than twelve parts of sugar in every hundred.

If the sugar cane were still propagated from seed, the task of selecting and encouraging the most profitable variety would be easy. But the cane has been so modified by thousands of years of artificial cultivation that it has lost the power of reproducing itself in a natural manner. It no longer seeds; and until some botanists undertook the difficult work of bringing it back to its natural state, nobody knew what the seed of the sugar cane was like. Recently several attempts have been made to grow seedlings and produce a new-old variety that could be constantly improved by selecting the seeds of the best canes. In spite of the various difficulties that are being encountered, this way may eventually prove to be practical and successful. As yet, however, the seedling is a botanical curiosity rather than a help to the planter.

All sugar canes from a commercial plantation are propagated from cuttings of stalk containing a bud. Every part of the cane stem having a perfect bud will put forth a new plant, but usually a few of the upper joints nearest the leaves are employed. When planted, the buds at the joints begin to spring forth, and at the same time a number of roots are thrown out around each joint. These roots serve to supply the young plants with nourishment, until they are advanced enough to put forward roots of their own. As the shoots develop the parent cutting decays, and the young plants, that now have roots of their own, grow rapidly with a plentiful supply of moisture and an abundance of hot sunshine. The growth of the crop is so rapid that it requires a continuous and generous supply of plant food. Only within recent years have cane-growers begun to realise the importance of keeping the soil rich and fertile.

The most effective method of restoring fertility is a rotation of crops. In American plantations where rotation is practised, cane is grown in the first year from cuttings, and in the second year another sugar crop is obtained from the shoots that grow from the stubble, but in the third year, beans, peas, or lucern are sown and ploughed under. But frequently corn is planted for a harvest crop in the third year; and peas, beans, or lucern are sown as a cover-crop, and ploughed in after the corn is harvested. There can be no doubt that the needs of the sugar cane were not fully

supplied in the old system. The matter was left largely to chance. In some riverside plantations the flooding water restored to the soil the plant food that was required, and some volcanic soils possessed so much nourishing material that no exhaustion was apparent. But on most plantations the canes never received the care that the beet was given in Europe ; so it naturally grew weak and subject to disease, and brought less profit to the planter.

In many parts of the tropics the climate is unsuited to the cane. In the greater part of upper India, for instance, the giant grass would not grow even from cuttings. For the rain does not fall in the warm, sunshiny weather when the canes need it. Even in the more favoured climate of the West Indies the planters are often in despair at a long spell of dry weather. The fact is that some system of irrigation is necessary in almost every land where the cane is grown. It has been practised from time immemorial in India, and carried out in China, Mesopotamia, Egypt, and Southern Europe, and in all the plantations that spread from Bengal. The West Indian planters and the planters in the Straits Settlements would save much money, and market their produce in large and regular quantities, if they adopted the irrigation system. On some British estates the water needed by the starving canes lies only six feet below the surface of the field. It could easily be raised by a well and a pump.

GRINDING THE SUGAR CANE TO EXTR[illegible]

In India the natives often irrigate their sugar plantations by a most primitive method of hand labour. Six men with closely woven baskets draw the water from a pond and empty it on the plantation. But only where human labour is very cheap can this slow and wearying process be employed. Sometimes the water is drawn from a well in a hide bucket raised by bullocks. But four bullocks, three men, and one boy are required on the day's work of this kind. A good piece of modern machinery could do the work of a multitude of labourers, but the natives are too poor to buy the plant and the fuel.

With the exception of the cost of irrigation, there is not much difference in the outlay of cane and beet sugar production. For in both cases the greater part of the work of cultivation has to be done by hand. So the labour supply is a ruling factor in both branches of the industry. In Java, where farm wages are about a shilling a day, and the best of modern machinery is employed in the treatment of the canes, the output of sugar is remarkably high. It is true that the Cubans produce a greater cane-sugar crop than the planters of Java, but this superiority is due to artificial circumstances—to the restrictions the Dutch Government impose on Java sugar, and the exemptions from high tariff taxation which the American Government allows to Cuban sugar. On the other hand, the Americans justly remark that there is something like a system of forced labour in Java, which gives the planters there a rather unfair advantage over the owners of plantations in more civilised and freer communities. All that we wish to [illegible]oint out is that the Hindoo pe[illegible] at an exceedingly low wage.

His economic cond[illegible]rown so severe, owing par[illegible]dinary growth of population [illegible]d of peace, and partly to the de[illegible]craftsmanship brought about b[illegible]tition with the produce of European [illegible] that it would be a great nation[illegible] if his primitive sugar industries [illegible] modernised, well managed, and e[illegible]panded. Such an industrial reform would [illegible] the field of employment, and in m[illegible] make all the difference between [illegible] and slow starvation.

The hand labour needed at an[illegible]ary sugar plantation of the modern ty[illegible]

great. The estate has first to be well drained; and when the drainage system is completed, pipes must be laid down for irrigation in the scorching hot weather. By deep ploughing, harrowing, dragging, and rolling, the soil is reduced to powder, and the cuttings are laid in holes which are gradually filled by hand as the shoots develop.

In the first part of the growing season there is a battle between the young canes and the weeds, and the weeds have to be kept down by constant cultivation of the soil. Then the work of irrigating the canes in the hot season has to be carried on. As the stalks mature, their bottom leaves decay, and these have to be constantly removed by hand in order to produce a heavy crop of sugar. Often the roots throw up suckers in addition to stalks. These must also be taken away when they grow too numerous. When at last the canes are ripe and ready for the harvest, they are cut with hatchets very close to the ground, and tied into bundles and taken to the mill. The roots are left in the earth, and from them springs another crop of smaller canes known as ratoons.

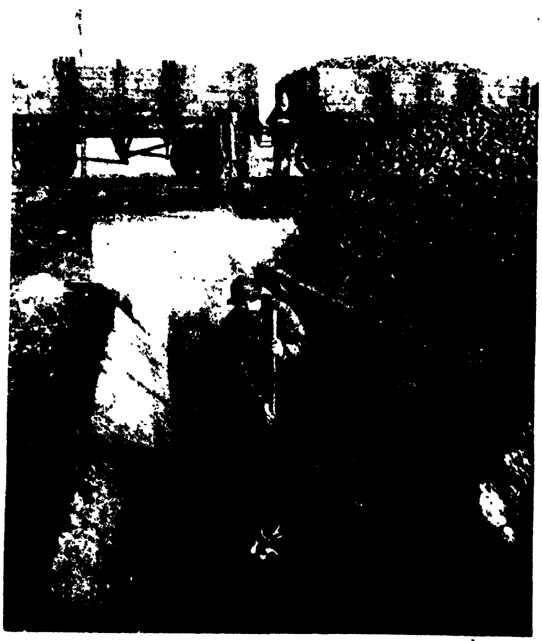
The roots will go on producing new shoots year after year; and, though their vigour slowly diminishes, it often pays to obtain some ratoon crops instead of using fresh cuttings and growing new plant canes. The loss in sugar is made up by the saving in labour. By manuring the roots with the first leaves of the plant canes, a ratoon crop can be obtained very cheaply. This is one of the advantages the cane-planter possesses over the beet-farmer. Ratooning, however, is not practical in Bengal for more than one year, for white ants swarm into the old roots, and work appalling havoc among the new canes. Constant ploughing is necessary in order to keep down the ants.

Few planters nowadays can afford to extract the juice from the canes they grow. A division of labour is necessary in order to produce a sugar that can compete in the market with beet sugar. Except in very large concerns, it is best to dispose of the canes to a modern factory; and it is the absence of these great power factories in India that puts the country at a disadvantage. Powerful and special machinery is required to extract all the juice from a cane, and thus make it equal in sugar production to the best kind of beet. The Hindoo peasant throws away a lot of sugar in the partly pressed cane that forms the refuse of his primitive wooden mills. In modern

THE INTERIOR OF A LARGE CANE-SUGAR REFINERY AT NETHERLAND, INDIA

SUGAR BEETS GROWN ON ENGLISH SOIL

THOUSANDS OF TONS OF BEETROOTS, AT THE ANGLO-NETHERLAND FACTORY, AT CANTLEY, NORWICH



WASHING THE BEETROOTS IN WARM WATER BEFORE TAKING THEM INTO THE SUGAR FACTORY

practice the canes are sent through as many as three mills, and the woody fibre that remains when all the juice is expressed is fed into the furnaces.

There is practically no cost of fuel in the factory, for the crushed and useless refuse supplies the heat-energy necessary to drive the plant. As the canes come from the plantation, they are placed on an endless chain that carries them in a matted mass to the rollers. A modern mill usually has three rollers, arranged one above and two below. The top roller has a double action. It helps to crush the cane passing through the first under-roller, and it meets the cane again on the other side, and crushes it between the second under-roller. On leaving the mill the crushed cane is delivered on to a second carrier that takes it to another mill or to the furnace.

The engine is generally of the non-condensing type; that is to say, the steam is ejected immediately after doing its work in the cylinder. But it does not pass out into the atmosphere in a wasteful manner, as in ordinary non-condensing engines. Everything is used up in the sugar industry at the present time. The leaves picked from the growing canes are employed either as manure or as fuel. The refuse from the mill supplies the place of coal, and the steam from the exhaust pipe of the engine is used to boil the sugar juice. It is by means of all these modern economies that the tropical planter is fighting his way to victory once more.

The juice extracted by the rollers is caught by the mill-bed, from which it passes to a collecting-tank. There it is strained and pumped up to the defecators. The raw juice is somewhat acid, and contains not only bits of cane and other suspended matters, but vegetable substances, such as albumen. It quickly ferments and deteriorates at the temperature of the air; so, on its way from the collecting-tank to the defecator, it is made to pass through a juice-heater. This stops all fermentation, and the juice then runs into the defecator. This is made in many forms, one of the simplest being a copper surrounded by a cast-iron steam-jacket. When the apparatus is filled with juice, some milk of lime is added to neutralise the acidity of the sticky liquor.

THE DIFFUSION PLANT IN WHICH STEAM EXTRACTS SACCHARINE FROM SLICED BEETROOTS

Steam is then turned into the steam-jacket until the juice is brought a little below boiling-point. The scum begins to rise quickly to the surface, while the impurities of a heavier kind sink to the

bottom. At some distance from the bottom of the defecator is a plug through which the clarified juice is drawn off, leaving the scum to settle upon the dregs. These are boiled together to extract the juice they contain, and then are pressed and steamed and washed and made to yield still more sugar.

In the meantime, the partly clarified juice, drawn off through the plug in the defecator, is sharply boiled in another copper, termed an eliminator. The heat causes fresh scum to be thrown up, which is removed by skimming. After this process the liquor stands for some hours in a subsider, where more dregs collect at the bottom; or, by a quicker process, it is forced through a cloth in a filter, and so freed from its remaining impurities. It is now clear and limpid, and all that has to be done with it is to boil it to grain—that is to say, it has to be heated to the point at which crystallisation sets up. The boiling-vessels are arranged in a series of twos, threes, and fours, the triple arrangement being that most commonly used.

The first vessel is heated by the exhaust steam from the various engines used in the factory. In the last vessel, a vacuum is maintained by causing the vapour evaporated in it to pass into a condenser connected with a good vacuum pump. The result is that the heat-energy of the steam in the first vessel boils the juice there. The vapour from the boiling juice passes into the second vessel, and heats the juice there to boiling-point. Then the vapour given off in the second vessel sets the juice boiling in the third apparatus. The evaporation in each succeeding vessel is slightly less than in the one preceding it, by reason of losses by radiation, and so on. But the economy effected in using a quantity of steam merely sufficient to boil the juice in a single vessel is very great. It is against highly efficient machinery of this sort that the peasant of India vainly tries to fight. Now that the European cane-planter in the tropics has been awakened to the necessity for equalling the beet manufacturer, he has become as scientific as his rival. He produces between ten and eleven million tons of cane sugar a year, including that made by the Hindu peasantry. Beet sugar, on the other hand, now amounts annually to six and a half million tons.

TESTING THE SYRUP IN THE LABORATORY

Of this amount Germany produces about one-third. Over a million acres of land are planted with beet, yielding somewhat over twelve and a half tons of roots an acre, and somewhat under two tons of sugar an acre. The beet-sugar industry of Germany is confined chiefly to Saxony, Brandenburg, East Prussia, and West Prussia. The region around Magdeburg is the largest manufacturing centre. The cost of production is said to be a little less than a penny a pound, but the retail price of sugar to the German consumer is high, on account of the consumption tax levied by the Government. In Austria the cost of production is still lower than in Germany, but taxation brings the average retail price to little under 3¾d. a pound. Wages in Austria vary from 7½d. to 1s. 3d. a day; and this, combined with efficient machinery and skilful organisation, enables Austria to export sugar to India as well as to Great Britain.

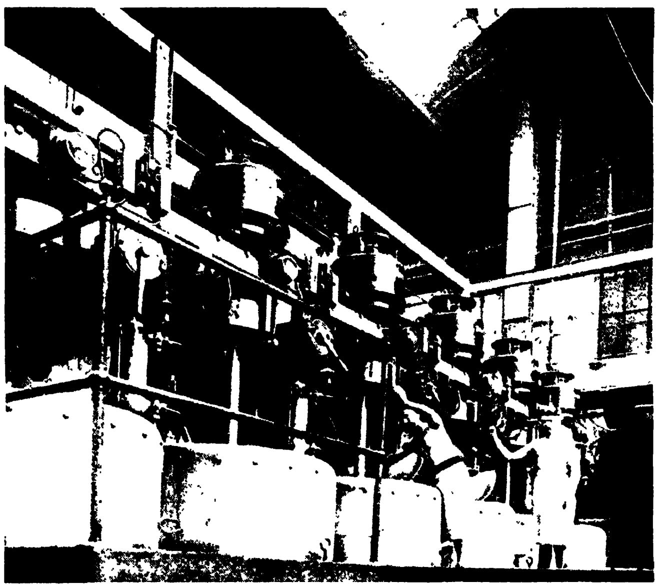
The beet that has completely changed the sugar industry during the last quarter of a century or so belongs to the same family as the mangolds used in cattle-feeding. The variety cultivated for its sugar was obtained from Silestra. It has a white flesh, and leaves of a green or purple colour. The sugar present in ripe beets is, when perfectly pure, identical in composition and properties with crystallised cane sugar. It is, however, difficult to refine beet juice so as to free it from the mineral salts produced in the plant. Hence commercial samples of beet sugar have not nearly so great a sweetening power as ordinary cane sugar.

The formation of sugar in the beet is not influenced so much by heat as by dry weather and unclouded skies during the autumn months. In Central France and

Southern Germany, where the summers are warm and long, the root does not succeed so well as it does in Northern Germany and Northern France. It would appear that the eastern, south-eastern, and northern counties of England, together with many localities in Scotland and a portion of Ireland, are well suited, so far as climate is concerned, for the cultivation of beet as a sugar-yielding crop. The best soil is one in which chalk, sand, and lime are mixed together; a good turnip loam containing clay and lime gets most sugar into the beet. On well-worked clay soils, with some lime in them, a succession of sugar crops may be grown without any manure. Some roots lately grown as an experiment in England show a higher sugar-content than German-grown beets.

We have a lot of clay which, if well drained and well cultivated, will give better results than Continental fields. The chief trouble is that the cost of labour in England is higher than in Germany or Austria: and as no mechanical means of gathering the crop are practical, the expense of cultivation in Britain might still leave the cheaper-worked foreign fields at an advantage. On the other hand, our soil is wonderfully fertile—it is, indeed, the most fertile in the world. So it is a question whether, if beet were grown in vast quantities, our fertility would compensate for the extra cost of labour. This can only be decided by actual practice on a large scale. It is the cost of putting up big, expensive factories, where power is produced and used in an economical manner, that is the chief risk. For each factory would require a great and regular supply of beets; and if bad crops were general in a close, rainy autumn, the manager of the factory would be hard put to it to keep things going profitably.

Cultivation is an easy but laborious affair. Twelve pounds of seed an acre are required, or double the quantity usually sown for common mangolds. Should the young plants suffer ever so little in spring by a night's frost, it is best to plough up the crop at once and re-sow. Like most roots, sugar beets require to be frequently hoed, and the fields must be weeded as soon as the plants are above ground. Hand labour of an experienced kind is needed in thinning out the beets, leaving twelve inches between plant and plant. Thinning out is a long operation, and adds considerably to the cost of cultivation. But if the roots are left either too close or too far apart, their sugar-content will be so diminished in quality or amount as to make the crop unprofitable.



THE CENTRIFUGAL MACHINERY FOR SEPARATING SUGAR CRYSTALS FROM MOLASSES

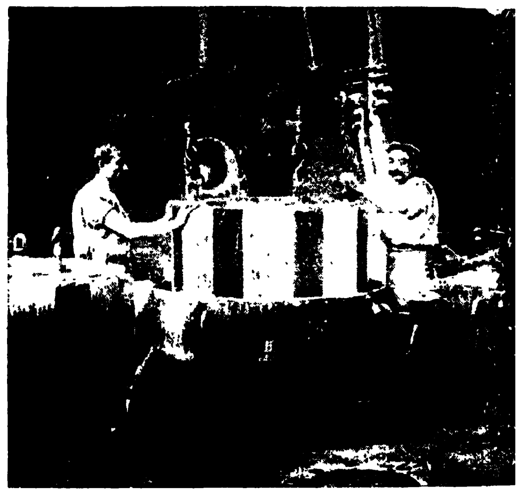
Hand labour is also needed in harvesting the beets just before frost sets in. No satisfactory machine has yet been invented either for topping the beets or harvesting them. So the whole practical problem in beet-sugar making turns on the cost of the labour supply. The expense of transporting beets from the field to the factory is another matter of importance. It is estimated to cost 1s. 8d. a ton for the first mile, and a little more than a shilling a ton for each succeeding mile. From this it is obvious that a ten-mile haul on waggons would make the cost prohibitive at the current prices of beets at the factories. In other words, the beet-fields must surround the factories they serve, and ropeways are largely used on the Continent for transport purposes.

Beet-sugar factories are expensive in construction and operation; and in order to keep them going the harvesting period must be prolonged as much as possible. It is usually necessary for the larger portion of the crop to be preserved, by stacking it and covering it with a light layer of earth,

which is increased in depth when the frosty weather sets in. This adds to the cost of production, and also slightly harms the quality of the beets, but it is requisite to keep the factory going in a regular manner.

The beets are bought at the factory at a price that varies with every crop. Samples are taken and tested for the sugar-content, and on the actual amount of sugar contained in the beet the price paid to the farmer depends. The first step towards extracting the juice is to clean and stone the roots. Formerly the beets were placed in drums of lattice-work that revolved in water. But now a stream of water is usually forced against the roots, to remove the mud from the roots. They then pass into a tank, where a still stronger force of water detaches the stones, that sink to the bottom, while the lighter beets are carried

RUNNING SYRUP INTO A MOULD



EXTRACTING THE MOULD WITH SUGAR

by the current on to an inclined grating, and tossed out of the machine by the action of a revolving drum. On leaving the washers, the roots are dried by a mechanical shaker, or passed through a series of power-driven brushes with whalebone bristles.

The cleaned and dried roots then fall into a hopper, and descend to a plate that turns horizontally, and carries three series of steel blades. This slicing-machine cuts the roots into slices about $\frac{1}{25}$th of an inch thick and $\frac{3}{8}$ths of an inch wide. Working with $1\frac{1}{2}$ horse-power, the machine can slice a hundred tons of beet in twenty-four hours. The knives have to be easily removable, for they are quickly blunted by the grit still remaining on the roots, and they frequently have to be taken out and sharpened. From the slicer, the ribbon-like pieces of beet go into a huge and curious piece of machinery, the diffusion battery, on the invention and perfection of which the beet-sugar industry entirely depends.

For many years the beets were reduced to a pulp and then pressed in order to extract the juice. But the process was so wasteful and inefficient that the beet sugar made by it could not compete with cane sugar. It is the modern diffusion battery which has given the beet-farmers an advantage over the sugar-cane planters. It depends on the curious principle of osmosis. There are two forms of substances in the vegetable cells that compose a beet. In one form are the colloids or gummy, glue-like matters which cannot be crystallised. In the other form are the crystalloids, such as the sugar and the salts which are capable of assuming a crystalline form. Now, when the crystalloids are dissolved in water they will pass through animal and vegetable membranes if there is water on the other side of the membrane. The colloids will not do this. The cell-walls of the beet form an excellent membrane. So when the beet is sliced up and placed in water, the sugar and other salts pass through the membrane of the cells, and mingle with the water outside. This is called osmosis, or diffusion.

The diffusion battery consists of a series of big cylindrical vessels, usually set in a circle, and communicating with each other by pipes. It is so arranged that the juice issuing from the bottom of one diffuser flows into the top of the next. The tanks

are equipped with a trap-door for charging with fresh beet slices, and a bottom drawer through which the exhausted beets are discharged. As the water passes from one diffuser to another, it draws out the sugar and salts from the plant cells until it becomes as dense as the undiluted beet-juice. At this point the diffusion action practically ceases, indicating that the extraction is completed. Heat facilitates the diffusion process.

A huge revolving hopper is erected above the battery, and as it circles round it distributes the slices into the circle of tanks. On the top of the hopper is the slicing-machine already described, fed by a bucket elevator carrying a stream of beets into it. The buckets catch the beets as they come from the second washer, and lift them up to the slicer and distributing hopper. All this ingenious system of automatic machinery saves much hand labour. The duration of the diffusion process varies from an hour to an hour and a half. The exhausted slices of beet are fed into a press that removes the water from the beet refuse, and converts it into an excellent cattle-food. So, as in the sugar-cane mills, nothing is wasted.

The raw beet-juice cannot at once be boiled into sugar. For it contains so much albumen and other impurities that the application of heat would only turn it into a gummy mass. The impurities are largely removed by adding a little lime to the raw juice, and then heating it, and passing carbonic acid gas through the lime solution. The heating of the lime solution causes most of the impurities to clot and rise up in a scum, and the injection of the gas dissolves the sugar which has combined with the lime. The solution is filtered, and the lime and gas treatment is repeated. In the last stage of purification, preparatory for the evaporation process, the solution is charged with sulphur dioxide gas, which removes more lime and other impurities, and leaves the juice of a light yellow colour.

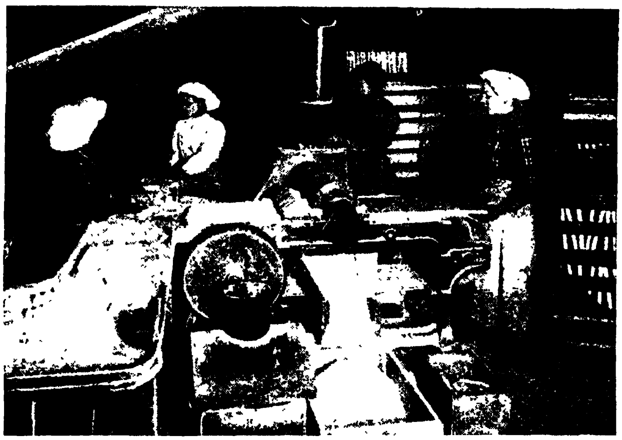
The evaporation is conducted in a manner similar to that described in sugar-cane boiling. The first pan is heated with exhaust steam, and by means of a vacuum the vapour it gives off is transferred to the next pan. When about 85 per cent. of the water has been removed in this way the syrup is again treated with chemicals, and bleached and passed into a vacuum pan, called the strike pan, in which it is further evaporated to a point of crystallisation. Much skill is necessary at this stage, both in the boiling and in the addition of fresh syrup, so as to regulate the growth of the crystals or the sugar grain. The sugar thus obtained consists of a varying amount of molasses enveloping the crystallised sugar.

REMOVING SLABS OF SUGAR FROM THE MOULDS FOR CONVEYANCE TO THE DRYING-STOVES

The molasses is separated from the crystals by whirling in centrifugal machines. This produces "first sugar." It is placed in storage bins, and the molasses is again boiled down. From it is then obtained "second sugar," which is dark in colour, and has to be specially treated to convert it into white sugar. The molasses now contains potash salts, and other impurities which prevent all further crystallisation. So it is either utilised as a by-product, or

freed from the potash salts and again evaporated and whirled. In some factories the process is repeated two or three times, leaving a final molasses so impure as to be fit only for a fertiliser or stock food.

The first processes in the manufacture of raw sugar from cane and beets yield in some cases an article more or less fit for direct consumption, such as Demerara and beet crystals. But, generally speaking, the colour, odour, and taste of raw sugars are indicative of impurities, which have to be removed by a further process of refining. Two modes of treatment are successively employed. In the first of these, sand and colouring matters and other undesirable ingredients are removed from the sugar solution by filtering and passing through charcoal; in the second mode of treatment, the sugar is separated from the rest of the impurities by crystallisation and machining. A great amount of beet sugar from Germany and Austria is merely washed by steam in a centrifugal machine. When the sugar is washed sufficiently the steam is turned off. The sugar is then taken out and melted to produce refined sugar. If a white grain is required the raw sugar is first mixed with a small quantity of ultramarine, and the final product is sifted in the warm state.



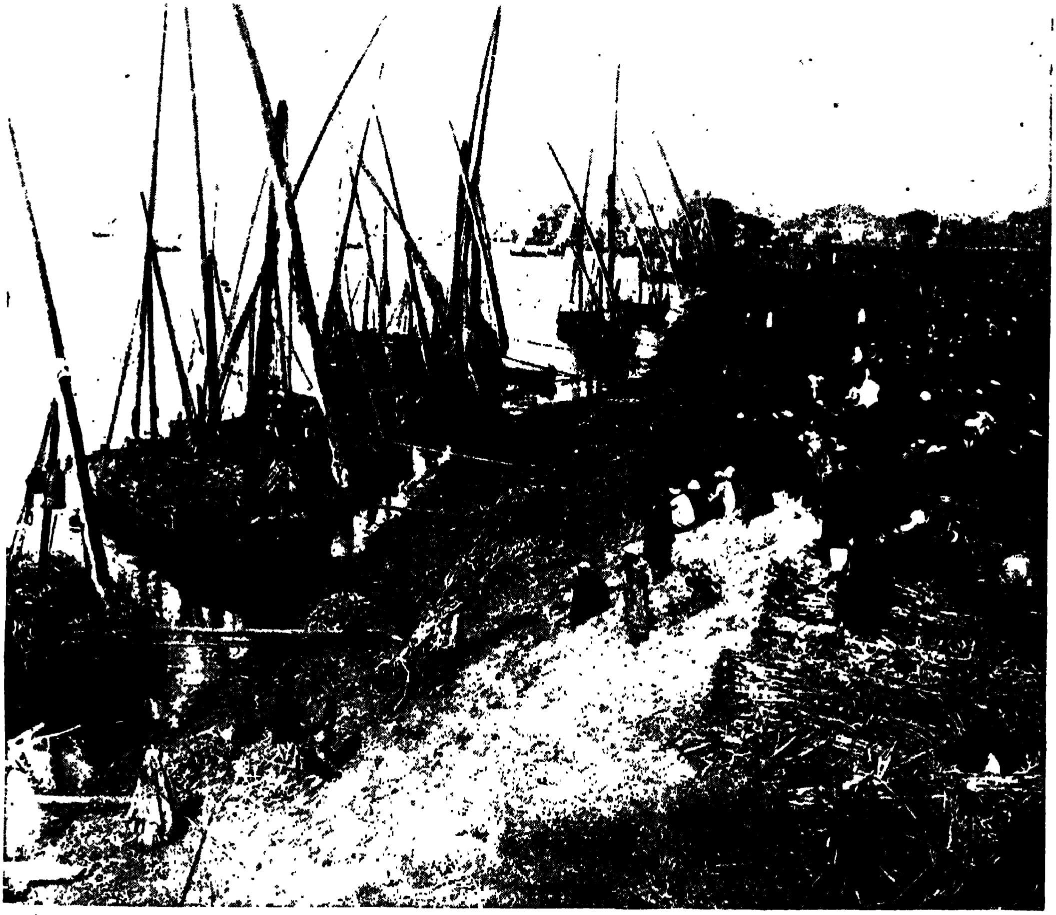
CUTTING SLABS OF SUGAR WITH CIRCULAR SAWS

In ordinary refining processes the sugar is melted in a huge pan called a blow-up, in which a small quantity of lime and phosphoric acid is used. The solution is then passed through a strainer, and conveyed into a filter formed of crumpled up bags of twilled cotton, slipped inside coarse hempen sheaths. After being filtered the liquor is bleached in a large iron cylinder, filled with animal charcoal, made from bones treated in a carbonising apparatus resembling a small gasworks. The bones are kept at a red heat for eight or ten hours, and then cooled and crushed into small pieces. In addition to its action on colouring matters, this animal charcoal removes many mineral and organic bodies, and leaves the sugar white and pure.

After the solution leaves the charcoal the sugar has to be re-crystallised down. This is effected mainly in a vacuum pan already described. The mode of boiling varies considerably with the quantity of the liquor and the class of refined sugar to be produced. By means of a proof-stick an experienced workman repeatedly examines the contents of the pan until he obtains the exact degree of stickiness he wants. He then admits more liquor into the pan, and this disturbs the equilibrium and the sugar begins to crystallise out. In making loaf sugar the boiled liquor is run into conical sheet-iron moulds, and the loaves are allowed to cool and solidify, and the syrup is drained off through a hole at the bottom of the mould. Little loaf sugar, however, is made nowadays. Its place is taken by moulded cube sugar made in the form of slabs or sticks, and afterwards cut into cubes or tablets.

The cheapest of all sugar is that made from starch. The starch is boiled with sulphuric acid in a big wooden tub fitted with pipes in which steam is circulated. When the action of the sulphuric acid is completed, the acid is removed by adding carbonate of lime. The muddy contents of the boiling-vat are run through a filter of sand or cut straw, and the clear sugar liquor is afterwards evaporated, either over a direct fire or by steam. The glucose so obtained is usually sold in the form of a syrup or in hard, shapeless lumps. From twenty-six to thirty-two pounds of it can be made from a bushel of corn, and the cost of manufacture is about a halfpenny a pound. It is used for table syrups and cheap sweets. All soft candies and toffees, and a large proportion of stick candies and caramels, are made from starch sugar syrup. The solid sugar is mainly employed for the adulteration of other sugars. Reduced to fine powder, it can be mixed with cane sugar in any proportion without altering its appearance; and since starch sugar costs much less than cane sugar this adulteration is immensely profitable

SUGAR TRADE ON THE NILE AND THE THAMES



LOADING NATIVE TRADING BOATS WITH SUGAR CANES ON THE BANKS OF THE NILE

A TYPICAL SUGAR REFINERY ON THE BANKS OF THE THAMES

The photographs on these pages are by J. Valentine, the H. C. White Co., Underwood & Underwood, A. Lyle & Sons, and others.

A RUSH TO THE CUSTOMS WITH SUGAR

IN ANTICIPATION THAT A TAX ON SUGAR WAS TO BE IMPOSED BY THE CHANCELLOR OF THE EXCHEQUER IN 1901, TWICE THE USUAL QUANTITY WAS RUSHED INTO LONDON IN MARCH

TRADE AND GOVERNMENT

The Strange Expedients by which England Failed to Gain Wealth, While Her Real Powers Lay Idle

CAN GOVERNMENTS HELP TRADE TO-DAY?

THE relations between trade and government form one of the most interesting chapters in the history and development of commerce. They are relations which have undergone remarkable changes during the progress of the world. There have been periods and places in which Governments have thought it their duty to control trade in many of its functions; there have been other periods and places in which the policy of non-interference has been carried to extremity. When government by military castes obtained, interference with trade often took the unhappy form of extortion, the trader being held to be little better than the natural prey of the soldier. When, gaining enlightenment, old-time Governments perceived that the lasting foundations of nationhood could only be founded upon peaceful pursuits, even military rulers came to recognise that trade was a thing to be cherished and not to be harassed. Protection and even privilege came to be granted to traders and their guilds and associations; and legislative enactments, sometimes exceedingly clumsy, mistaken, and futile, came to be passed for their welfare, or for what was conceived to be the national trading interest of the time.

In all times a settled government, capable of maintaining order within a certain area, has been the first condition of commerce. We refer not only to the protection of a nation from armed forces of invasion, we refer also to the protection of lives, liberties, and rights within the nation itself. Until within the borders of a nation, government protected the individual in his craft or trade, secured the individual in the produce of his labour, and made laws respecting the enforcement of contracts between individuals, there could be little or nothing which could be dignified as trade.

As to foreign commerce, this could only develop as States became strong enough and respected enough to make it difficult or impossible for foreigners not to respect contracts into which they had entered with their citizens, and reputable and honest enough to make it desirable for foreigners to come to their ports with merchandise, or to gain admittance for their ships to foreign harbours. It is a remarkable illustration of the unequal progress of the different races of men that whereas long before the birth of Christ, Phœnicians, Greeks, Romans, and others, had learned how to transact considerable volumes of internal and external trade, today, in 1913, nearly two thousand years after the beginning of the Christian era, we find Asiatic peoples whose trade is insignificant, and African people who scarcely know the beginnings of trade.

We know from the earliest written records made by men that commerce began long before recorded history. Egypt, Babylonia, and Assyria were versed in trade thousands of years B.C.—so much is certain. The great rivers of Egypt and Mesopotamia nourished production, created great States, and afforded an obvious and elementary means of transport. Natural water-carriage suggested artificial canals to these ancients, and an abundance of fertility and production, augmented by the institution of enslaved producers by all-powerful military rulers, created great cities and large accumulations of wealth. Later came the enlarged civilisations of the Phœnicians, the Greeks, and Romans, whose activities saw commerce extended to the coasts of the narrow seas and even beyond. Wherever conquest was sufficiently thorough to give security, there commerce flourished. But centres of security arose and fell, and today many of the ancient centres of trade—

Nineveh, Babylon, Tyre, Sidon, Carthage—are left but glorious names.

In our own country the beginnings of security came with the Roman, who, as it is so difficult to realise today, ruled these islands for four hundred years. The Romans were essentially a military rather than a commercial people, but they gave the peace in which alone production and commerce could live. There must remain considerable uncertainty as to what was the precise effect of the Anglo-Saxon conquest of Britain, after the withdrawal of the Roman legions, upon the economic structure of the country. It is a fascinating problem which we can only commend to the study of the reader, and pass to the re-establishment of security in what became England.

The early Anglo-Saxon communities could have had little trade as between one part of the country and another, although somehow they must have traded for iron, that first among the prime necessities of advancing mankind. Their chief personal property took the form of cattle, which were rigorously protected in the common interest; it went hardly with the man found in possession of a beast which he could not show to have been bought in the open market.

The Gradual Growth of Foreign Trade After the Conquest

Long before the Norman Conquest there were the beginnings of commerce with the Continent. Charlemagne, who died in 814, gave protection to English traders in return for a similar privilege granted to Frankish merchants in England.

The exportation of wool, which for so long remained a principal feature of English commerce, had begun. William the Conquerer who, as we know by the Doomsday survey, conquered a country of between 250,000 and 300,000 people, found a nation which had made considerable progress since the rupture of the Roman-British civilisation so many centuries before. Money was increasingly, if still sparingly, used, and the value of standard weights and measures had been recognised. During the centuries immediately succeeding the Conquest, during which the Norman and the Saxon were undergoing a slow process of fusion, much progress was made in establishing governmental control of the various standards, and in the reign of Richard I. the uniformity of weights and measures was enjoined by statute.

During these years also, customary fairs and markets came into existence in all districts—many had already been in existence for very long periods; the requirements of local trade were thus met, and Government wisely recognised their status.

Interference with foreign trade also appears in the meagre records of the time of the Norman kings. Customary dues or payments at the ports, commonly called "Customs" duties, were an obvious, and therefore an early, device for the raising of revenue. In the reign of Richard I., an import duty was levied on wine, and accounted for at the King's Exchequer. In the reign of King John, Customs duties were payable on both imports and exports and we know that duties were paid on imports of wood, salt fish, etc., and on exports of wool and leather.

The Wise Protection of Merchant Strangers Trading in England

In the reign of Henry III., but 150 years after the Conquest, we find it enacted that foreign merchants shall be used well. The law ran "Merchant strangers (if they were not prohibited before) coming into this realm as well by land as by water, shall be well used, and buy and sell without any manner of evil tolls, except in times of war, in which case they are to be intreated as the English are in the enemy's country." And in the next reign we find it enacted for the benefit of foreigners that in case of shipwreck, "Where a man or a dog or a cat escape quick (alive) out of the ship, the goods if saved are to be kept and restored to the owner within a year and a day." Herein is shown much progress in civilisation, and recognition of the great value of the visits of foreign traders. It should be observed, however, that it was not always that the private English citizen shared the view of the Government as to the desirability of intercourse with strangers.

Early Attempts to Restrict Trade by Cornering Iron for English Use

In the reign of Edward II. (1307-1327) we get the prohibition of the importation of cloth made beyond the sea "upon forfeiture of the said cloths, and the merchants further to be punished at the King's will." In the reign of Edward III. (1327-1377) we get a legislative recognition of the value of iron to the nation at large. "No iron made in England, or iron brought into England and there sold, shall be carried forth of the realm of England upon pain of forfeiture of double the money to the King." The reign of Edward III. was marked by the enactment of a very large number of important statutes regulating or interfering

with trade, and they clearly embody the conception that trade is a matter of supreme national concern.

The statute just quoted endeavours to prevent the loss to the nation of any iron which has been either made in it or imported into it. Similarly, it was sought to prevent the loss of any gold that had once been imported, although this was obviously more difficult. If we trace the history of the English Customs' tariff in the thirteenth, fourteenth, and fifteenth centuries, we meet with an ever-increasing volume of regulations and restrictions as to oversea trade.

Early Failures to Understand the True Nature of Wealth

The alien was allowed to trade at the port the stuff he brought, or the stuff he desired to export, but he was not allowed to do home trade while here.

Again and again in these centuries we find it enacted that the precious metals must not be taken away. Acts of Henry IV. (1399-1413) and Henry VII. (1485-1509) said that, "No gold or silver in coin or in mass is to be carried over the sea without the King's licence, saving reasonable expenses, upon pain of forfeiture of the same." And a statute of Henry VI. ran, "Gold or silver must not be carried out of the realm upon penalty of forfeiture of the same, one quarter to go to the informer." Here, of course, was the embodiment of the Mercantile Theory of trade, which so long crippled the commerce of the world. Gold was confounded with wealth, and it was deemed a great thing, nay, *the* great thing, to get as much into the country as possible, and to keep it there.

Primitive Attempts to Keep Foreign-made Goods Out of the Country

Side by side we find enactments designed to keep certain merchandise out of the country altogether. A statute of Edward IV. (1461-1483) ran, "Certain merchandises wrought are not lawful to be brought into the realm of England or Wales to be uttered and sold upon penalty of forfeiture -viz. (to quote only a few of the things specifically mentioned), woollen cloths, laces, ribbons, silk, harness, locks, hammers, pinchers, dice, tennis-balls, purses, gloves, anything wrought of leather, shoes, knives, scissors, chessmen, playing cards, rings for curtains, ewers, hats, brushes," and half the penalty was to go to the person who played informer and seized the goods. This law was the first serious act against the importation of foreign manufactures. It is of interest to add that in the reign of Edward III. a law was passed to prohibit corn exportation this was with a view to conserving the home product for the home consumer, and so to reduce its price; a generation later this law was repealed.

The Government's efforts to promote trade, however, did not stop with such measures. Statutes were passed to encourage the wool industry, not only by restraining raw wool exports and striking at woollen cloth imports, but by encouraging the immigration of foreign weavers. This was done as early as the beginning of the first half of the fourteenth century. The conception of State interest in industry and trade grew with the years, and the statesmen of Elizabeth endeavoured by every then recognised means to promote commerce. They firmly held the Mercantile Theory, and viewed with pleasure the exportation of more stuff than was brought in, believing that the "balance of trade" had to be paid in gold, and was the only possible means of enrichment for a nation.

The Ingenuity of the Eighteenth Century in Restricting the Country's Foreign Trade

The policy of restriction of foreign commerce came to be further developed in the seventeenth, and especially in the eighteenth century, when Customs ingenuity reached a very high pitch, its complications being manifold. The policy of restricted dealings with foreign countries, and the Mercantilism which saw in gold obtained by an excess of exports over imports the true aim of trade, received further complications in its application to English Colonies. By the time of the reign of William III., Sir Thomas Pittar says in his official history of the British Customs Tariffs, "the accounts of the Customs, and even the process of paying duty, gradually became matters of such complexity as to place the public entirely at the mercy of the immense official hierarchy which sprang up as a necessary result of a system which none but exper s could possibly understand." And so things remained for over a century. By the reign of George III. (1760-1820) the condition of the Customs had become such that none but a skilful expert "could positively say what might be the sum total due upon any particular article, or to how many cumulative rates of duty it might be liable."

In 1787, Pitt reformed and consolidated the duties; yet still an expert was needed to expound the 1414 subdivisions of the tariff which remained after his reforms.

Later, between 1820 and 1842, the reform of the tariff was largely accomplished, many

duties and restrictions being swept away; and in 1845 and 1846 the policy of open ports went to further lengths, foods being practically relieved of all duties, save a few required for revenue purposes. In 1853 many of the remaining minor duties were abolished, and in 1860 further simplification reduced the tariff to only twenty-six revenue items, as compared with the 1500 with which the nineteenth century began.

We have said that tariff complications were increased by differential rates of duty as between foreign and colonial products. Early in the nineteenth century discriminating duties against European timber in favour of British North American timber was found to be an evil from a naval point of view. A Select Committee of the House of Lords reported upon the matter in 1820, and reported that Canadian timber, the importation of which had been favoured by the tariff, was, with the exception of red pine, softer, less durable, and more subject to dry rot than Baltic timber. A Commissioner of the Navy gave evidence that of twenty-six frigates built of Canadian and Baltic timber, those built of European wood were twice as durable as the others. Accordingly, the Committee suggested a reduction in the tariff on foreign wood; and in the following session Parliament accordingly increased the duty on Canadian timber to 10s. the load, while decreasing that on Baltic timber to £2 15s. There were many other differential duties of this kind, and they existed to a much later date. For example, in 1842 the duty on foreign timber was £1 10s. per load, and on colonial timber only 1s. per load.

In spite of all the duties and discriminations which had been practised for so long, it cannot be said that up to the eighteenth century great success was achieved in founding or stimulating British industry or commerce. Britain was still largely an agricultural country, in which industry had made slow progress. Raw materials were exported, and manufactures imported, in spite of all the efforts to reverse the process. So accurate a writer as Stanley Jevons, writing of the wool industry as it existed in Britain in the middle of the eighteenth century, says: "Wool had been for a long time esteemed the staple produce of the country. We raised the raw material in plenty, but were so unskilful in its manufacture that all the Acts of Parliament that could be devised, all the arts and watchfulness of the Revenue officer, could not prevent it being 'run' for the manufacturers of France and Holland. No efforts of the legislature could enable us to compete with foreigners, and mistaken restrictions only contributed to keep the whole country stationary." Indeed, even towards the end of the century, as it is difficult to realise, France was a greater manufacturing country than England.

What artificial means had failed to do, what the complicated efforts of so many Governments in so many centuries had failed to accomplish, was brought about by the discovery that Britain possessed, in her coalfields, the means to raise steam, the means to exercise power as it had never before been exercised in the world. Coal and invention, acting and reacting upon each other, as we have described in the early chapters of this work, and employing a great mass of people who were enabled to live by the wealth created by manufactures, which grew with great rapidity, soon changed the position of Britain amongst the nations. The funds with which Pitt met Napoleon arose out of this Industrial Revolution, which changed Britain from a poor, struggling country, with a stagnant population, into what has been called "the workshop of the world." It was, of course, the demand of the rapidly growing coal-based industrial population for cheaper food which led to the great Corn Law agitation and the Tariff Reform movement of the 'forties.

Let us show the character of the revolution by reference to the production of pig-iron as from the middle of the eighteenth century.

BRITISH IRON PRODUCTION SINCE 1740

	Tons
1740..	17,000
1788..	68,000
1796..	125,000
1806..	258,000
1825..	581,000
1839..	1,244,000
1847..	2,000,000
1854..	3,070,000
1864..	4,768,000
1870..	5,963,000
1890..	7,904,000
1900..	8,960,000
1910..	10,200,000

This is an exceedingly illuminating record. In 1740 British iron production amounted to only 17,000 tons, which is today a negligible quantity. By 1788 the output had quadrupled. In eight years more it had again doubled. In ten years more it had doubled again. In 1825 we were producing thirty-four times as much iron as in 1740. We see the industrial revolution at a glance. Jevons also pointed out how

rapidly raw cotton imports rose at the end of the eighteenth century and beginning of the nineteenth. Here are the facts.

COTTON IMPORTS INTO BRITAIN

	lb.
1785	17,993,000
1790	31,448,000
1801	54,203,000
1811	90,310,000
1821	137,401,000
1851	273,250,000
1860	1,390,939,000

Such was the effect of the application of coal-power-driven machinery to the cotton industry at that turning-point in British economic history. Trade grew as though conjured by a magician's wand. But more important still is the test by population. The stagnation of England and Wales in the first half of the eighteenth century is a most remarkable fact.

ENGLAND AND WALES: POPULATION 1600–1910

Year	Population
1600	4,800,000
1630	5,600,000
1670	5,800,000
1700	6,000,000
1711	6,200,000
1721	6,200,000
1731	6,200,000
1741	6,200,000
1751	6,300,000
1761	6,700,000
1771	7,100,000
1781	7,600,000
1791	8,300,000
1801	8,900,000
1811	10,200,000
1821	12,000,000
1851	17,900,000
1901	32,500,000
1910	35,700,000

We see that from 1700 to 1751 the population was practically stationary, *the increase being a mere* 300,000 *in fifty-one years*. It is apparent that the country had arrived at economic stagnation.

In 1751-61 there was a gain, however, of 400,000 people, and a further 400,000 were added during the succeeding ten years. The decade 1771-81 put on 500,000, and the succeeding decade added as many as 700,000. By 1801 the population had risen to 8,900,000, or nearly two-thirds as many again as in 1700! Compare the first half of the eighteenth century with the second half; *in the first half the population rose by* 300,000, *and in the second half by* 2,600,000! That may be truly termed a summing up of the change wrought in England and Wales by the use of coal.

It is abundantly necessary to observe with care the relevance of these all-important facts to the subject of this chapter. They remind us that there are natural conditions and resources which triumph as no arts of government can triumph. Looking at the above table of years, we see it begins with a period of a century and a half—1600-1751—during which every sort and kind of Customs expedient, and many other governmental devices, were experimented with in scores, hundreds, or even thousands of different forms. The result of all the efforts, good and evil, and many of them undoubtedly well-intentioned, left the nation stagnant during a great part of the period, and not only stagnant but backward in the arts, as compared with several other nations. Then, without any change of trade policy, with all the old expedients still at work for good or for evil, we see a rapid expansion taking place, not because the national policy had changed—for it had not, as we have seen in some detail—but because scientists and inventors had shown us how to make use of natural resources, which, during all the long centuries of Briton and Roman and Saxon and Dane and Norman, and the people founded on these, had been the unsuspected, untried, undeveloped possession of what we now call England and Wales.

No more striking object lesson could be adduced to enforce the proposition that a people cannot afford to neglect the arts of industry and of trade. We see how it is unhappily possible for men, even of the white races, to live for thousands of years in a land without realising its material wealth, and yet while exhausting all sorts of curious governmental devices to procure the desired and eluding end.

We think now of the King who, properly recognising the virtues of iron, enacted that what iron was made here should be kept here, and what iron foreigners could be induced to bring here should not be allowed again to depart. One wonders what he would have thought of his well-meant but trumpery legislation if he could have foreseen that his country had the power to produce millions of tons of the metal which he coveted for his people's good. Similarly, one thinks with a smile of the days when it was enacted that wool must not go out to feed Dutch weavers, and that foreign cloth must not come in to displace British labour. And we wonder what High Parliament would have thought if it could have been borne in upon its members that below the

surface of English soil there lay sleeping a mass of stored energy which needed but to be unloosed to draw to it wool from all the world, and to create, without an ounce of Governmental assistance, the greatest woollen industry in the world.

It is a great and unforgetable lesson, truly, in the comparative importance of things, and in the limitations of the powers of government. Are we to conclude from it that it is vain to study the arts of government? Are we to deem the interference of Governments in industrial and commercial affairs unnecessary?

Is Government Interference in Industrial and Commercial Affairs Unnecessary?

The answer to these questions must be a decided negative. There are many forms of Government interference, some developed and experimented with by many nations, others as yet but little exercised. We may not even hastily conclude that some of the old expedients were wrong, because they failed under the existing conditions to develop the national wealth. We are able to affirm that England had come to stagnation in spite of them; it is possible that worse things might have happened without them. Some of them, however, we can clearly perceive, in these enlightened days, to be wrong—even childishly wrong.

But we can see as clearly how many things were not tried in those old days, and we know of State experiments now being pursued in the world which are fructifying before our eyes. Suppose that it had occurred to the statesmen of the spacious days of Elizabeth that learning was a key to unlock not only the minds of men but the treasures of the earth. Even at that time the world was not without science. The ancient Greeks had made pretty experiments with steam. When Elizabeth came to the throne in 1559 Leonardo da Vinci, who left us so many extraordinary and pregnant conceptions and investigations (including a treatise on flying), had been dead forty years.

Neglect in Olden Times of Training People for Trade

It is an interesting subject for speculation what the world might have realised by now in the way of material wealth if ancient Governments had given more attention to the training of intellect and the investigation of fact, and less to the vain attempt to gain wealth at the expense of foreigners, as though the gain of one people must necessarily be the loss of others. Today we have no excuse whatever for misapprehension. We know what trained minds are capable of. We know that man is rising to a mastery of the powers of Nature, and that secret after secret is being unfolded. The white races, through the widespread training of at least the well-to-do portions of their citizens, are producing every year a growing number of scientific students who push on into the fields of the unknown with an ever-increasing determination. It yet remains to be seen what mankind will accomplish when the inheritance of knowledge is made the birthright of all, and all comprehend the meaning of the commercial and industrial miracles with which they are surrounded.

Unquestionably, Governments can do much for the nations for which they are responsible by training the youth. Can they do more? The answer to this question is being written in experience with an increasing rapidity. We see Governments ever endeavouring to provide a better material framework for the nation's life.

Modern Methods by which Governments Can and Do Help Commerce

The modern Government cherishes transport in all its forms, creates cheap and reliable postal, telegraphic, and telephone services, and sets up Departments of State to watch the interests of agriculture, of industrial production, and of home, foreign, and Colonial commercial intercourse. Methods differ in the prosecution of these objects, but there is unanimity in making them functions of government.

And government goes much further. It realises, in modern times, the salutary conception that the rank and file of the nation must not only be educated, but protected in their employments. Civilisation is all for interference in this matter at the beginning of the second decade of the twentieth century in which we write, and the fact may be recorded as one of the most hopeful and promising of our time. The statesmen of the sixteenth century tried to prevent the undue exploitation of the poor; a later, and in this respect less enlightened age saw the increasing population produced by factory industry crowd itself into the cellars and garrets of unregulated towns.

Fortunately, we have been for some time endeavouring to repair such folly, and the future is bright with hope in this respect. In 1912-13 there is a Bill before Parliament, certain soon to become law, to prevent work in certain trades in underground rooms. Factories, of course, have for long been regulated; they must be clean, they must

be sanitary, and they must afford a certain minimum of space for each worker. The hours of women and children are regulated. Proper time has to be allowed for meals. The hours of miners are regulated. Employers have to compensate workmen who meet with accidents while in their employ, or to compensate the dependents of workmen who are killed in their service. Dangerous trades, such as railway work, mining, and industries using poisonous or dusty materials, have to work under restrictive regulations. A scheme has been devised in England, as in Germany, of National Health Insurance, which provides medical treatment, pay during illness, maternity benefit, and special treatment in tuberculosis. Last, but not least, the State has even entered, as it did in the Middle Ages, the domain of wages. We have an Anti-Sweating Law which applies the principle of the minimum wage to certain scheduled trades, and which appears in 1912-13 to be succeeding wonderfully well. More remarkable still, we have established a minimum rate of remuneration for miners, and there are many who advocate the extension of the principle to all trades and industries.

What Will be the Attitude of Governments in the Future towards Monopolies?

As to many of these things, there is general agreement that it was well to do them, and their results are seen and acknowledged to be beyond question good. As to others, there is doubt as to the limits rather than as to the principle of the interference, and all the signs of the times point to the extension of Government regulation of industry to protect and cherish the lives of the mass of the people.

Beyond these things, acknowledged so generally to be desirable, there lie the questions we have had occasion to review in connection with our study of that grave feature of modern industry and trade—viz., monopoly. The necessity to use capital in very large sums in order to use it most economically, and to prevent waste of mental and manual labour, leads straight to the erection of enormous undertakings which in many respects come to possess the appearance, the powers, and even the demeanour of Departments of State. When we communicate with them, we feel that we are not writing to an individual, or to individuals, but to a mysterious entity which appeals to us as a thing rather than as an aggregation of human beings. We receive a reply which tells us that "All letters must be addressed to the company, and not to individuals"—it is a characteristic phrase.

In the great industrial nations these agglomerations of capital, wielding powers undreamed of even late in the nineteenth century, and the existence of which was deemed impossible by the early British academic economists, have aroused many fears, and their position is ever being more freely discussed.

The Entry of the Governments of Great States into Trade Regulation

In America we have seen the head of one of them, the Steel Trust, propound in evidence before a State Commission, set up to inquire into the challenged methods of his undertaking, the proposal that the United States Government should control the trust and even regulate its output and its prices. In Germany, Ministers of State from time to time issue grave warnings to capital combinations as to their conduct, and always the German Government is seeking to gain a stronger and more intimate control of the industrial and commercial life of the nation. We also see a great Government—that of the United States—undertaking at its own cost the greatest engineering feat ever accomplished by mankind, the cutting of the Isthmus of Panama, an action which brings it into direct responsibility for the conduct of a business which affects all nations, and as to which all nations must in their own interests hold it answerable. In the Australasian Colonies State interference has gone further still. Nationalisation and municipalisation are common, and wages are closely regulated.

Governmental Interference that Seeks to Avoid the Mistakes of the Past

Thus, whatever fate befell governmental interferences in England from Saxon rule to that of the House of Hanover, we see Governments everywhere not only undismayed by State experiments, but ever widening them as the years go by. Our study may perhaps have helped us to perceive in what things to avoid and in what things to welcome State interference. If we succeed where our forefathers failed it is no great credit to us or discredit to them; for they were engaged in business enterprises based on scientific principles that had never been studied systematically, and were only slowly understood; whereas we have the advantage not only of extended experience as a guide, but also the serious thought of many acute and reflective minds.

"THE NEAREST YET" TO THE POET'S DREAM OF THE FEDERATION OF THE WORLD

THE MOMENTOUS CONFERENCE OF REPRESENTATIVES OF THE LEADING NATIONS OF THE WORLD AT THE HAGUE IN 1907

THE PEACE OF THE NATIONS

The Perplexing Difficulties of Establishing and Enforcing International Justice

THE FINAL TRIUMPH OF CIVILISATION

The introduction of civilisation to the individual man, and to the internal government of States, is a parallel and analogous process. The one illustrates the other at many points. Exactly the same features appear also, in some degree, in the international relationships of States; and whenever the parallel is completed by the nations, civilisation will have received its supreme confirmation, and war will be left behind as a disgraceful memory. We wish to suggest here that what has happened in the case of the individual man, and in the case of civil government, is bound to happen in the relationships of nations; and that it is no more impossible that wars shall cease, and peace reign, than that man's unruly impulses should be curbed by custom, or that communities should work in loyal co-operation for the common benefit. Further, we wish to mention some of the difficulties in the way of the coming of the world's peace, and to indicate paths by which it may arrive.

The original man, who lived at the back of the long story of evolution, was a bundle of simple impulses. He fed, he loved, he fought, he sought comfort on the spur of the moment. It has been said that animal intelligence is limited to deciding what to do under the circumstances of the moment. The original man was a creature of the circumstances of the moment. He battled or fled, pursued or took his ease, as the prompting came. He lived preferably alone with his mate and family, in a state of suspicion tempered by courage, with little foresight, little combination, little self-suppression. To him life was a state of war.

The superior savage of today, who has organised his life much more fully than the original man could have done, and who is bound by innumerable tribal customs, is in many respects the plaything of surface impulses. He has the shallow spontaneity of the child. And that child! How luxuriantly untrained are all its instinctive tendencies, till they have been lopped and directed and cultivated. Now leap forward to the evolved result that has come by long and slow change from the original man, and by swift and skilfully guided change from the wayward, impressionable child, and see the difference in the well-braced, experienced man of the world. He scarcely ever acts from impulse. Reason, foresight, calculation, wisdom, are his mainstays. He distrusts profoundly the promptings of surface feeling, and knows that the power of restraint is as potent as the power of initiative. If he were to fall back into the clutches of his most elementary instincts he would know that he had lost hold of the best part of his manhood.

In short, the individual man has been transformed throughout at least ninety per cent. of his being by the process of civilisation, and the process is still going on. He is constantly receiving new moral endowments, such as pity for suffering everywhere; and is shedding old traditions, such as the expiatory power of blood. Individually, he has already reached in civilised lands the renunciation of war, though war was one of the mainsprings of life to his remote ancestors. He has no wish to go forth and pour lead into the bodies of his fellow-men. He has no belief in war. He only accepts it as a custom of the nations, because nations, as a whole, are less advanced in civilisation than the individual man. What has happened to the individual man will certainly happen at last to the nations.

The case of society from the aspect of domestic government is just the same. Instead of each man being a law to himself, and bringing about his wishes, or pursuing

his revenge, by his own powers, the people of every civilised land live with each other under the common peace by universally admitted arrangement. In place of individual strife, the law runs and peace reigns. There are facilities for the settlement of all differences in the name of justice; and any breaking away from this condition is universally reprobated, and held to be deserving of punishment. The securing of justice is a communal and not an individual matter, with immense benefit to all. No longer can the armed man swagger along the pavement—except in soldier-ridden Germany—and use his weapons to support his own importance, or avenge fancied wrongs. The civil peace gives its calming protection to all, and that, too, without display or fuss. The strolling policeman is the visible sign of this substitution of universal justice for private force, and his work is so slight that it consists chiefly in his being a sort of general Providence to the inept rather than an active upholder of the law. Security and freedom reign everywhere, and what is needed now is chiefly attention to the amenities of life, to manners and bearing, and not to peacefulness or honesty.

The Peace that has Settled Down on Private Life by Civic Agreement

It is true that there are scattered outbreaks, when we see a recrudescence of the original violence of mankind. The ruffian becomes riotous; the burglar, born chiefly of a crime-bred clan, plies his craft in the intervals of prison life; and here and there unrestrained feeling leaps suddenly into murder—but these are occasional breakings away from the general rule, sporadic outbursts that, in a scattered way, will long give evidence of social shortcomings, bad breeding, or disordered nerves.

The main feature of the position is that whereas man in his original unrestrained state, and even in his supposedly civilised state, until quite recent times, was a prey to violence, over wide areas of society, so that life was never very secure, now he lives under an all but universal hush of peace and law-abiding content. From society, as organised in such countries as Great Britain, individual violence has practically been banished. If we picture the state of things that existed in England a hundred years ago—the time of duels, prize-fight bruisings, press-gangs, and so forth—and now, the advance in social organisation to the exclusion of violence has been far greater than the advance that would be required to remove war from the customs of civilised States.

If the progress of mankind, individually and civically, has been so great, in relation to acts of violence and bloodshed, why should their action as national aggregates lag so far behind that they are all preparing to slaughter each other in settlement of any differences that arise? The theory of government is that the ablest and most thoughtful men control national policy; but we see these men, presumably the finest products of Time, and of each race, coolly accepting the most barbarous and primitive of all arbitraments, inherited from the days before reason, justice, and sympathy had become dominant in the administration of human affairs. It is a sorry sight indeed, and strongly suggests that in the government of nations the finest minds have not yet reached the top.

The Self-Confidence of Strong Nations a Bar to Arbitration

In our comments on war we gave some reasons why the war spirit is kept up. Against the acceptance of any system of adjusting national claims except by direct conference between the Powers concerned, with an appeal to arms as a resource held in reserve, perhaps the strongest objection is the sense of self-confidence felt by each of the three or four most powerful nations. Conscious of their ability to hold their own, without deferring to anyone else, they ask, "Why should we commit our affairs to the decisions of any body of men outside our frontiers? If we mean to be just in our dealings, are we not capable of seeing what justice demands on our own account? Let us do justice by all means, but keep our right arm strong and free to insist that it shall be justice. And there is no safer way of securing that end than by talking straight to an opponent with sword in hand."

The Settled Conviction of Moral Men that there are Worse Things than War

That is a position that is not easily overthrown when the Power concerned has enormous power, influence, and responsibility, as in the cases of Great Britain, Germany, and Russia. It is easy enough for small States, which count for but little in the great aggregate of the nations, and can only be protected from aggression by all forms of peaceful arbitration, seeing that they have no ambitions or power of expansion, to enunciate abstract theories that will never reduce their own comparative importance; but any surrender of freedom of action by more powerful States, with greatly complicated problems of government always calling for settlement, has exceedingly grave

practical bearings. In fact, peace settlements for great States and little States raise entirely dissimilar problems.

Hideous as war is, irrational though it be as a form of settlement of differences, the nations will never abandon it for any cut-and-dried theory that does not take into account exigencies of existing nations that are deeply based on historical developments. There are some things for which the most peaceful members of the most peaceful nation would fight. There are many conditions natural to a free and independent people for whose preservation all who have any comprehension of what is really important to mankind would willingly die. We can conceive surrenders in the name of peace that would be far worse than war. The question can never be settled on lines of abstract theory, however perfectly the theory may seem to hang together; but what can be done is to spread the revulsion against war so as to make it impossible for civilised people to take up an attitude that will provoke war; to create the sentiment that the quest of peace is at all times infinitely more honourable than the descent into war; and it is possible, without much delay, to prepare the machinery that will make peaceful understandings easy.

The Search for a Tribunal to which Nations Can Appeal Confidently

Even that approach towards the removal of national differences from the region of quarrelsomeness is beset with difficulties. Obviously what is needed is a tribunal in which all nations can feel complete confidence. How is such a tribunal to be formed? What types of national differences could it deal with? Can we hope that all disputes liable to lead to war would be submitted to such a tribunal?

This is the system evolved for the settlement of industrial disputes which often reach the verge of social war. A conference invariably ends every conflict, whether military or industrial. When the fighting can go on no longer the reasoning which should have prevented the strife comes into play, but with the weaker opponent placed at a manifest disadvantage by the strife. Can the nations evolve a tribunal which will have a grasp and power and dignity, and sense of justice and transparent honesty, that will warrant any great people in leaving its affairs with the tribunal at least for a verdict? Let us see what has already been attempted in this direction.

Two conferences have been held at the Hague—in 1899 and 1907—and more recently an International Naval Conference in London, with a view to reduce armaments, substitute arbitration for war, and simplify, in case of war, procedure that otherwise might lead to international trouble. The first Hague Conference was called on the invitation of the Tsar of Russia, and met on May 18, the Tsar's birthday, the chair being taken by the first Russian representative, M. de Staal, the then Russian Ambassador to England.

Where the Hague Conference Failed and Where it Partly Succeeded

The primary object of the Conference, as explained in a letter sent round to the Powers by the Tsar, was to make suggestions for the limitation of armaments, with a view to ultimate disarmament. In that respect the Conference was a failure. It is true it passed a resolution that "the restriction of the military burdens which at present weigh upon the world is greatly to be desired for the material and moral welfare of humanity," but it only discovered the difficulties of the problem when it came to close quarters with it, difficulties which it admitted it could not solve. And, indeed, since that time the cost of armaments has gone on increasing at a previously unexampled rate.

Though the section that should have made recommendations respecting armaments failed, the other two sections of the Conference completed useful work. The international rules of both land and sea warfare were to some extent revised by a second section; and a third section, dealing with Arbitration and Mediation, produced a valuable scheme that should point the way to useful future developments. Largely through the influence and tact of Lord Pauncefote, the chief British representative, and Ambassador to the United States, a scheme was formulated for a permanent international tribunal of arbitration open to any of the Powers signing the agreement, or, under certain conditions, to other Powers.

The Constitution of the Tribunal Suggested at the Hague

The tribunal, it was decided, should sit at the Hague, each Power being authorised to nominate four members eminent in International Law, who might act as arbitrators. If two Powers came to the tribunal for a decision, each of the two Powers could select two arbitrators from the whole list, and the four so selected, or a neutral Power, could choose from the list a fifth arbitrator as umpire. These five would then come to a decision on the case submitted to them.

WAVING HER MYRTLE WAND, PEACE STRIKES A UNIVERSAL CALM THROUGH SEA & LAND

THE FAMOUS SYMBOLICAL PICTURE ENTITLED "PEACE," BY SIR EDWIN LANDSEER, R.A., IN THE TATE GALLERY

The relegation of disputes to this fairly formed international tribunal was left voluntary, a proposal by Russia to make it obligatory so far as money questions are concerned being defeated by Germany.

The Second Hague Conference did no constructive work that would compare with the elaboration of machinery for permanent international arbitration by the First Conference, its discussion revealing further the great difficulties that surround all arrangements between nations which might seem to bind them to a certain course, while the future circumstances at the time when action must be taken cannot possibly be foretold. The last International Conference, meeting in London, took the important forward step of establishing a Naval Prize Court, Great Britain, the United States, Germany, France, Italy, Austria, Russia, and Japan each appointing one judge, and smaller Powers who join appointing between them seven other judges.

By these Conferences something substantial has been done towards ventilating the question of arbitration, and probing the difficulties of international agreements ; but the Hague Tribunal has not been used as it might have been, though once it has been brought into operation successfully.

The Hope Raised by the Attitude of the Working Classes Towards War

Some driving force is needed to convince Governments that they must look first to arbitration and not to war. That force exists in its most potent form in all the organised Labour societies of the Great Powers. Wherever the voice of Labour speaks on its own account it asks for peace and denounces war. It is so universally in Great Britain. It is so in France. It is so, though with less insistence, in Germany. The workers of the nations are understanding that whoever else profits by war they do not. On them comes the brunt of the hardships that war entails, the chief loss of life, the legacy of incapacity from wounds, and the lasting burden of expense which follows even the most successful war. To them comes none of the so-called glory of conquest, nor the reward of national achievement. And in their eyes the men of other countries are fellow-workmen primarily, and not natural enemies intent on doing them damage. While no section of the public is more patriotic than the working class, the usual pretexts for war leave them cold and critical. It is from these millions who are used as pawns in the dreadful game, which is the culmination of diplomatic plots and fears and false ambitions, that the world must look for the demand that wars of aggression and fantastic rivalry shall cease. Kings, as a rule, would be glad enough to have it so, for war is always liable to bring insecurity to thrones. The men who are trained to think of war as the final expression of a nation's force and character are the great menace that is, the exponents of so-called statecraft, acting hand and glove with militarism, and perpetuating an evil tradition.

Why Cannot Kings Make Themselves the Direct Ambassadors of Peace ?

Mr. Andrew Carnegie, who has honourably distinguished himself by his attempts to advance the cause of Peace, which many public-minded people seem to neglect in sheer hopelessness, sees in the constitution of the London Naval Prize Court a more promising, because simpler, form of machinery than the Hague Tribunal. In this case each of the great nations appoints one direct representative. Mr. Carnegie has expressed the opinion that if such an international gathering decided that wars shall cease they would cease. But why could not the rulers of the great nations be the men to make that decision ? That would be simpler still, and far more influential. Does anyone suppose that there is any power lurking unrecognised in any modern nation that would rise in protest against an agreement by kings and presidents to end war ? On the contrary, there would be almost a universal chorus of admiration. The kings could begin a reign of peace if they were men enough to feel the reality of the problem and statesmen enough to try to solve it.

The Difficulties Caused by the Tendency of Nations to Break their Word

If the mind to do this great work of blotting out war by the constitution of a Court of International Law, in which all disputes could be legally and peacefully settled, were to appear in the midst of the nations, prompted by kings, welcomed by the masses, and overwhelming the comparative few who remain devoted to the thought of war, the difficulties to be overcome would still remain serious in character.

How, for example, would the decisions of an International Court be enforced if certain States remained recalcitrant, or broke away from the agreement, or were too uncivilised to keep a pact of peace ? What pressure could be brought to bear on a nation that proved dishonest in the face of the whole world ? Could war, or the threat of war, be

used to enforce an agreement the essence of which was the abolition of war? The way out of this difficulty is the preservation of national good faith; and can that be trusted?

Until recently, though there has been some phrase-making about the perfidy of nations, a strong undercurrent of belief has been retained in the essential integrity at least of some of the nations. On that integrity all international superstructures have been built. But, unfortunately, a shattering blow at the very foundations of national honesty appears to be threatened from a wholly unexpected quarter. The lead in all movements for the wiser government of the world, by reason, on lines of peace, has always come from Great Britain and the United States of America. These two great nations have illustrated, again and again, how disputes may be settled by an appeal to justice. They exemplify that close approach of nationalities in friendship and mutual interest which it is hoped may sooner or later be possible all round. What they are, in their relations as interwoven nations, it is hoped other people may become. But now it appears as if even the American Republic, the land of liberty and generous sentiment, may not be trusted to keep the simplest, plainest, and most explicit promise.

An Unexpected Blow at National Honour Threatened by the American Republic

If this should prove to be the case with respect to the Panama Canal—the point is not quite settled at the moment of writing this, but repudiation of engagements is openly and formally accepted in some official circles—then the very foundations of national character are shifting, and the simplest elements of morality need to be learned afresh by one section of the Anglo-Saxon race. Such action as the American Republic threatens to take would more than undo all that her people have attempted in the past by way of international conciliation, for what shall it profit the nations if they enter into the most solemn covenants, based on unselfish concessions, and then unhesitatingly repudiate them at the first convenient moment?

The supposition behind all agreements between nations is that honour will suffice to carry the agreement through. If honour fails, justice fails, reason fails, and in the end peace fails, for the rogue cannot always be trusted to take his own roguish way, and must be effectively guarded against. The greatest blow ever struck at human progress, because struck at the honourable organisation of nations, seems to be contemplated by at least a section of the American Republic, and it has a grave and depressing bearing on the whole question of the abolition of war. If the American Republic talks only sentiment about such subjects with her tongue cynically in her cheek, what nation is there that can be trusted?

But though nations are thrown back on themselves, by cynically engendered distrust, each seeking to keep its own house in safety seeing that the best of the rest may prove unreliable when the test of fidelity to honour comes, the story of evolution tells us plainly that this low national morality will be left behind eventually.

The Possibility of Swift Change in Favour of Peace and National Morality

If as much advance is made in the next hundred years as has been made in the last hundred years, to go no farther, the reason and conscience of man will then have concluded that the repudiation of national honour is a mistake, that cutting throats is no true settlement of any human difficulty, and therefore that war must cease and that mankind, after all, has sense and uprightness enough to carry out arrangements by which violence will be brought to an end. What is needed is a wider acceptance of the idea of peace.

Enormous changes can happen quickly in these days if men think together. At present war holds the field. It is tacitly acquiesced in, though the mere fear of it bars men by the million from fruitful labour, misdirects and wastes the labour which it allows, imposes grievous burdens on all who work, and absorbs the wealth that should raise the level of human happiness. Preparation for it is paralysing, and its actual coming is devilish.

A Crime that Dies in the Daylight of Humane Thought

To such a state of moral and economic disease there is but one antidote—ideas. War lives on the glamour of a tradition. Its own set of ideas, vague but showy and familiar, are in possession—a medley of sentiments in which heroism, sacrifice, love of display, and a crude patriotism mingle. But so irrational is it in essence, so uneconomic in operation, so contrary to all else that man is struggling towards in his rise from savagery to a life of beauty, that it must be rejected whenever the mass of mankind can be induced to think the question out afresh. And the means for swiftly spreading everywhere that regenerative thought are ready to our hands today.

THE MIXTURE OF RACES

A Great but Insufficiently Studied Problem Confronting American Peoples

DO RACES MIX THROUGH LOW TYPES?

THE mixture of human races furnishes us with the most stupendous of all problems in eugenics. National Eugenics, as Sir Francis Galton loved to call it, is another matter, and a very important one. But we assume that in a modern nation we have a relatively uniform kind of human being to deal with, and that our task is simply to encourage the superior and discourage the inferior strains there. International Eugenics, as we may call it, is another matter, of vastly greater difficulty, and it is one which the facts of the changing world are now thrusting upon us as never before. We have to discuss it on the basis of a very slender store of real knowledge, unfortunately, as distinguished from hearsay and prejudice. It is to be hoped that the case will be different when the International Congress of Eugenics meets for the second time, which will probably be in San Francisco in 1915.

In this country, or for our French neighbours, it is National Eugenics that matters. Under the present conditions of the world we have to fear our Continental rivals, and therefore eugenics presents itself as a national question, a problem of "national defence," as a French Minister of Finance has described it. There is immigration of foreign races into this country, but that does not constitute a large racial problem, and cannot be regarded as affecting substantially the racial qualities of our people. But in America the case is very different. The United States has no serious rival or dangerous neighbour. National Eugenics is not there a question of maintaining the numbers and the vitality of a nation against the menaces of a rival across the water, or on the other side of a merely political frontier. But our Transatlantic cousins have a problem of their own, which is also a problem for the whole of mankind in the years to come. This problem is chiefly one in human genetics—namely, what happens when we cross members of markedly different races.

Of course, we ought to be able to refer to recorded genetic data, but there are none such to serve us. The astonishing fact is that there is not, in any university in the world, a Chair of Human Genetics. The laws of heredity in man are only being studied by a few Eugenists here and there, with scanty resources and opportunities. Yet all the world over the most remarkable observations might be in the making, for mankind is now conducting a multitude of experiments upon itself, with consequences which no one can yet foresee. Let us consider one of the simplest and oldest of such experiments, which has been repeatedly cited in the controversy over Mendelism during the past decade.

We remember that Mendel crossed individuals who were notably contrasted in certain characters, and found that those characters did not blend or effect a compromise in the offspring, but that there was something which he called *segregation.* Instead of getting a three-foot-high race of peas when he mated talls and dwarfs, he obtained only talls, and in the next generation a proportion of three talls to one dwarf. The same is conspicuously true for contrasts of colour in many plants and animals. But, said the critics of Mendelism, however that may be as regards plants and animals, it certainly does not apply to man, for everyone knows that, when white and black are mated, the mulattoes are a compromise between the colours of their parents. There *is* blended inheritance, and no trace of segregation, Mendelism notwithstanding. So the critics said; and if it were true that Mendelism, which is worth so much

when we cross subhuman species, should fail us when we effect crossings in our own species, certainly we should be deprived of the best hope of real knowledge in this field for many decades past.

Since that first criticism, however, Major Hurst, and others following him, have shown that Mendelism does apply to at least one case of colouring in man, and that is the colouring of the iris of the eye. There brown is dominant to blue, and true segregation occurs, so that the proportions of colours in the eyes of any human pair whose own ancestry is known can be predicted with as much certainty as the colours of sweet-peas, and by the same law a beautiful and astonishing recent example of that "uniformity of Nature" which science constantly reveals. It may be, therefore, that we require further knowledge before we can confidently say that Mendelism does not apply to the colour of the skin as well.

It is commonly assumed that mulattoes, of intermediate pigmentation, continue to produce mulattoes when they intermarry. It may be so, but in fact the case has not yet been critically investigated, though the American students should surely clear it up before long.

Evidence that Human Race-Mixture Proceeds on Mendelian Lines

The fact may be, as Professor Punnett has pointed out, on the analogy of many cases among the lower animals, that "several interacting factors are concerned, and that the pure white and the pure black are the result of combinations which from their rarity are apt to be overlooked." But, however that may be as regards whites and negroes, already we are obtaining some remarkable evidence as to the true segregations from the cross between the darkly pigmented Eastern races and the white. Professor Punnett has recorded one such case, where in the offspring of two parents, one white and one Eurasian, there have appeared several pure blondes, several children of intermediate colouring, and several who were very dark. In another case, where a very dark Eastern lady married a white man, "some of the children were intermediate in colour, but two were fair whites, and two were dark as dark Hindus." Professor Punnett's comment is as follows: "This sharp segregation, or splitting out of blacks and whites in addition to intermediates, strongly suggests that the nature of the inheritance is Mendelian, though it may be complicated by the existence of several factors which may also react one upon another. Nor must it be forgotten that, in so far as these different factors are concerned, the whites themselves may differ in constitution without showing any trace of it in their appearance."

If this be all that science really knows as yet of such a relatively simple thing as skin-colour, evidently we are not yet in a position to assert what happens to mental and moral characteristics, or even to such physical characters as health and energy, when races are crossed. Non-scientific commentators are doubtless very ready with opinions, but no one who had spent a week upon the serious study of genetics could listen to such uncritical assertions.

The North American Indian Now Ruled Out from Race Mixture

Let us just look at the problem as it is now presenting itself in America, and thereafter we may consider whether the recorded history of mankind can help us at all in predicting the future. The first white immigrants into North America found certain human beings already present. These Red Indians no longer constitute a racial problem, though their history may teach us something as regards the future racial problems of our own great Eastern dependency. It was found that the Red Indian seemed to have extremely feeble powers of resistance to tuberculosis, a disease with which he was unfamiliar. The same has been observed for the negro and the Eskimo. It is not a question of climate, but of the biological state of the race in relation to the particular parasite.

The Decimating Spread of the Diseases of Civilisation Among Untried Races

In India we are introducing tuberculosis among a race which used to be far less afflicted by it than ourselves. This disease is rapidly spreading in the tropical world. Our own domestic animals share with us diseases in common, and become liable to our maladies when they assume our habits. It is the same with the native races of man when they begin to imitate the ways of the European. Apparently, races which are unfamiliar with a disease are specially prone to contract it. That seemed to be the case with the Red Indian in North America, and it seems now to be the case in various of the tropical possessions of the British Empire. As the late Sir Rubert Boyce pointed out, "Thus we are brought face to face with the curious fact that whilst man is steadily stamping out

certain diseases which for the most part interfere with his commerce, there are a few diseases associated more especially with his comparatively luxurious way of living which are not kept under, and are especially apt to spread quickly amongst the native races who come in contact with us and copy our methods."

But, as everyone knows, the Red Indians in North America are now specially protected, living by themselves in "reservations," and thus their special racial susceptibility to certain diseases does not constitute a problem for the rest of the population, nor does the question of intermarriage arise to any great extent.

Vastly more serious is the second problem which the white settlers in America posed for themselves, in the introduction of the negro from Africa. It need hardly be observed that not one negro existed in America until they were there imported; and that importation has had the effect of bringing into existence several millions of human beings who would not otherwise exist at all, either in America or anywhere else, for it is now clear that the negro in Africa was not increasing in numbers at all. These negroes now constitute the great problem in the United States.

The Unusual Tendency in the United States to Race-Mixture

Like other races unfamiliar with the disease, they display an extreme susceptibility to tuberculosis, and are thus a danger to their white neighbours. They are also extremely susceptible to the dangerous charm of alcohol and many other neurotic drugs, notably cocaine. All of these drugs require a high measure of self-control in those who would resist them, and thus readily find victims in a race naturally deficient in self-control.

It is notorious that the impulses of sex tend to be marked among the victims of consumption, who are thus very often extremely prolific, and it is still more notorious that alcohol has a similar effect. But, unfortunately, the birth-rate among the negroes in the United States is largely the product of miscegenation, occurring under conditions which are worthy of careful study. For we have to remember that there is a very real tendency in human beings to prefer members of their own race. The great fact called "race prejudice" is the expression of this preference. Indeed, Professor Karl Pearson's statistical studies have led him to the conclusion that this tendency goes much further, so that tall people tend to marry the tall, brown-eyed to marry brown-eyed, and even those with a tendency to longevity to marry their like. This general tendency for like to marry like is called "homogamy" by Professor Pearson, and must have an important influence upon the history of mankind. It is well known that, when white travellers visit strange countries, members of the two races concerned think each other peculiar, abnormal, and *hideous*. Sex-attraction is normally between persons who have some affinity in physical and psychical constitution.

Will Not Mixed Races be Born from the Least Satisfactory Members of Each Race?

From these well-established facts the writer would draw an important inference, which detailed study in the future may verify. It is that, in general, the mulatto population of the United States, for instance, must be drawn from the less satisfactory members of both races. To this rule there will doubtless be hosts of exceptions, and yet the generalisation may hold. The sex-attraction between members of races so extremely diverse may exist on account of worthy affinities between individuals; and everyone knows that the United States' population includes many distinguished citizens of mixed parentage. But, too often, persons of such parentage must be the progeny of those whose association depended upon the influence of alcohol, or upon morbid and undesirable forms of sex-attraction in persons of passionate and uncontrolled type.

This is, at least, probable, as the mere extent of illegitimacy among such unions shows, and it may go far to account for the defects alleged to exist in the offspring.

The Marked Change in the Racial Character of the Inhabitants of the United States

If, further, we allow for the influence of environment, in its many forms, we shall begin to see that the existing impressions upon this subject cannot have any scientific value. It is necessary for the various sources of fallacy to be removed before we can state what is likely to happen, under fair conditions, when members of races so diverse intermarry. To some of the elements in the future study of this problem we shall return.

This particular case of the mixture of races is, however, by no means the last which the present history of the United States affords. No more negroes are being imported into that country, but there is an incessant stream of immigration of other kinds.

Students of demography in the United States are well aware that, in recent years, the racial character of the immigrants is markedly changing. In former years the Irish, the Dutch, the Germans, furnished the typical immigrant. Of course, this involved intermixture of racial types, but the range of variation was relatively small. Nowadays things are much changed. The German immigrant has almost disappeared; the Irish are far fewer than they used to be. The races of Western and Northern Europe in general are no longer emigrating as they once did to the United States.

The More Rapid Increase by Birth from non-Anglo-Saxon Parentage

The stream of immigration is now directed notably from the South-Eastern parts of Europe. The Italian and the Greek, the Levantine, Armenian, Syrian, and Jew — these are the races from which the population of the United States is now recruited, and the results must be momentous.

Intermarriage is not what happens first—nor at all, as yet, to any extent. But extensive and competent study of the "maternity statistics" in the United States, as communicated by Dr. Hoffman to the First International Eugenics Congress, has shown that these immigrant peoples, more or less dark-skinned, and racially far removed from the peoples of North-Western Europe, are those from whom young America is being chiefly recruited. According to the State census of Rhode Island in 1905, 72 per cent. of married Protestant women were mothers, 80 per cent. of Roman Catholics, and 88 per cent, of Jews. The native-born married women had an average of just over two children apiece, the lowest of all, while the figures for not-native-born women go up as high as 4·42.

The Need for More Careful Study of the Problems of American Stock

Dr. Hoffman reaches this conclusion: "Vastly more important than the multitude of general and social economic facts are those statistics of what, for want of a better term, may be called *human production*, and which disclose what must needs be considered the most alarming tendency in American life. Granting that excessively large families are not desirable, at least from an economic point of view, it cannot be questioned that the diminution in the average size of the family, and the increase in the proportion of childless families among the native-born of native stock, is evidence of physical deterioration, and must have a lasting and injurious effect on national life and character."

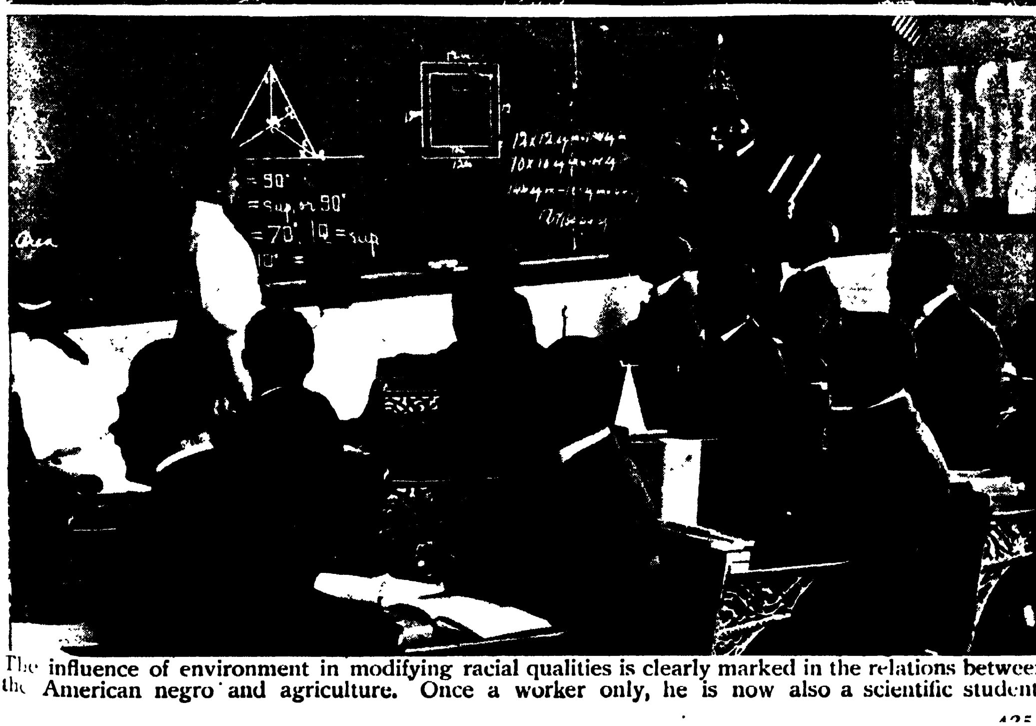
These conclusions by Dr. Hoffman do not seem to be by any means proved, and would need to depend upon an adequate study of the natural quality of those whose superior fertility he has demonstrated; and we may add that he has not informed us how many of those born to the various types of mothers die. As to Jewish mothers, we know their children survive, but it is probable that the very great excess of the birth-rate among the alien mothers may be much reduced in effectiveness by a higher death-rate among their offspring in many groups. Still, even when that was allowed for, no doubt we should find that the racial characteristics of the population of the United States are undergoing profound changes, which would very much have astonished the Pilgrim Fathers. Mr. Roosevelt's assertions about race-suicide are clearly justified, in the main, by Dr. Hoffman's figures of maternity among native-born American women.

The Anglo-Saxon Stock an Example of Advantageous Mixture

A higher birth-rate, with gradually increasing numbers, among the races by whom America is now being invaded, will ultimately lead to very extensive intermarriage, with results which no man can foresee in the present state of our knowledge.

Exact genetic knowledge we have none, but we may look to history and to the existing mass-evidence, such as it is, to see what it teaches us. One clear lesson emerges. It is that the mixture of races is not, as such, disastrous. The so-called Anglo-Saxon race leads mankind in many particulars, but history shows that this "race," so-called, is really a mixture of a very large number of elements. No one can walk along the street, even in a provincial English city, and fail to observe the extraordinary variety of human type, and of human combination, that confronts him everywhere. Great variations in stature, colour, type of hair, and details of physiognomy must strike the most casual observer; and no doubt the psychological differences are no less great. The "Anglo-Saxon race" is really an assemblage of individuals produced by the most extraordinary degree of "mongrelisation" or intermixture; and perhaps the day may come when it will be possible to trace many facts of our national character and history to the great diversity of types which we comprise.

THE NEGRO—OLD STYLE AND NEW STYLE



The influence of environment in modifying racial qualities is clearly marked in the relations between the American negro and agriculture. Once a worker only, he is now also a scientific student.

But certainly this anything but pure-bred race is not degenerate, nor of low type, taken as a whole. And if we look at the dominant peoples of the world we find no evidence in favour of the view that inter-breeding involves degeneration of any kind. The reverse seems to be the fact. It is isolation that involves the degeneracy of a community. The lowest types we know, such as the native Australian, the Tasmanian, the Patagonian, and many others, are races of men marked by considerable physical uniformity, who have been isolated for a long period, and who have certainly not ascended in type by reason of their purity of race.

The Verdict of Anthropology that there are No Pure Races

On the other hand, such nations as Great Britain and Japan represent the results of many invasions, and the infusion of many strains at various periods in the past. If we ask an anthropologist of today to show us a "pure" race, he will reply that he cannot name one, but that the nearest to such a standard are the lowest he knows.

Further, Mendelism and the modern study of heredity which we owe to such great botanical workers as De Vries, of Amsterdam, have taught us that we must revise our idea of "race" altogether. Every individual is composed of a combination of certain genetic factors, a kind of "living mosaic," as it has been termed. Now, one pattern in mosaic may differ greatly from another; and if we have thousands of such patterns to look at we may arrange them in groups, which, if we like, we may call "races," or "species," and in larger groups, which we may call "genera." Yet it is evident that, by substituting one piece of mosaic for another, we could gradually transfer any individual pattern from one "race" to "another." It is so in the living world, and we must modify our ideas accordingly.

The Problem of Race-Blending Largely a Question of Personal Traits

We require to think of the individual of any race as a "living mosaic," who displays a special combination of certain genetic factors, and to recognise that substitution of one such factor for another may be possible to any extent. The only difference between the living and the lifeless mosaic is that in the former there is something which the Mendelians call "coupling," and "repulsion" of factors, so that we cannot always remove any one piece of "mosaic" without at the same time removing another, or we cannot insert a piece without causing the expulsion of another. Otherwise the analogy comes surprisingly close to the facts.

One other large lesson Mendelism teaches us, if we wish to succeed in the task of studying human race-blending. It is that these genetic problems cannot be studied *en masse*, or by the method of mass statistics. This method may give us a rough impression, but even that may very well prove to be wrong, as we are beginning to suspect even in the apparently obvious case of the skin-colour of mulattoes. There is only one way of getting at the facts. We must take individuals of known ancestry, and study their offspring. Then we must observe cases where such offspring marry the offspring of other parents of similar ancestry, thus obtaining conditions similar to those of Mendel, when he mated his "first filial generation" of peas among themselves; and we must then study the characters of the next generation.

This is simple enough, and only conforms to what Mendel proved to be necessary nearly half a century ago, but it has never yet been done for mankind. Men and women have repeatedly made the necessary experiments in the course of their own lives, but the results have never been recorded.

The Difficulty of Knowing which Traits are Units and which are Complexes

Further, let us note that Mendel obtained no results by *general* estimates of the resemblance of individuals in the various generations he studied. He took one precise, definite character at a time, and its opposite (or the lack of it), and studied its distribution in the stock. Then he took another such contrasted pair of characters and studied them. Now, it seems a reasonable proposition that, as human beings are at least as complicated as peas, we should require no less discrimination and detail in our study of human genetics than Mendel found necessary when studying the genetics of the pea. But, with the exception of one or two pedigrees regarding skin-colour, such as those we have quoted above, not one clear record anywhere exists of the inheritance of single characters among the offspring of individuals belonging to different races. We cannot yet even define the unit-characters in virtue of which races of men differ from one another, nor state which are dominant and which recessive, nor how they may be coupled with one another. The reader may realise how ridiculous and deplorable the popular assertions on the subject appear to those who know how little we yet know.

The sixth of the invaluable "Bulletins" issued by the American Eugenics Record Office is called "The Trait Book," and has been compiled by Dr. C. B. Davenport, with the help of many competent advisers. A preliminary attempt has there been made to define a large number of human traits, and their opposites, in such a way as to provide students of heredity with a number of pairs which they can study by the methods of modern genetics. Even so, only study can show which of these traits are really units, and which are complexes. Professor Bateson and Miss Saunders found that the presence of minute, simple hairs on the stems and under surface of the leaves of certain stocks were due to the simultaneous presence of three factors in the germ-cells.

The Study of Human Blends at Present a Tantalising Complexity

If such a simple character in a plant has such a complex genetic origin, we may begin to guess that when we come to talk of the inheritance of honesty, intelligence, musical ability, conscientiousness, and self-control among the offspring of parents of different races, it is just possible that we may be out of our depth. If we consult the heading "mental traits" in this little book, we shall learn how much we have to learn. Two famous psychologists have done their best for this section, and eight pages are filled with a bare list of mental traits and their opposites. Of not one of these can we yet assert that it is a unit; the simplest of them may be due to the concurrence of half a dozen factors, and they are all capable of being influenced by environment, education, imitation, and suggestion.

Turning over these pages, we cannot even say which characters belong to, for instance, white people and negroes. Thus, to which shall we respectively assign quickness and slowness, jealousness and unjealousness, discretion and rashness, brightness and gloominess, placidity and irascibility, enthusiasm and indifference?

The Unproved Assertion that the Race Most Evolved Psychologically is Dominant in a Blend

So soon as we begin to think seriously we see that individuals vary so widely within a race as to render ridiculous any attempt at making general assertions on such matters. The only thing we know for certain is that we know nothing about them. We cannot yet even state the facts about skin-colour. "Prognathism" is one of the skeletal characters put down for study in the Trait Book. It is a very obvious characteristic of the negro jaw that it is prognathous, or projecting, whereas the jaws of the white man have a vertical profile, or are orthognathous. We do not yet even know whether these opposite characters are a Mendelian pair, or, if so, which of them is dominant and which recessive.

It might have been hoped that the Eugenics Congress would reveal some knowledge upon this great question of racial mingling, which will be perhaps the supreme characteristic of the coming time. If such knowledge existed, it would have made an appearance. Professor Morselli, of the University of Genoa, read a paper on "Ethnic Psychology and the Science of Eugenics," brief reference to which will show how complete is our ignorance. According to this student, "It is always the races strongest biologically and most evolved psychologically which impress their characters upon the descendants of these unions. This fact renders difficult the formation of truly mongrel or hybrid races." This assertion seems positive and satisfactory enough. According to it, the higher type "wins through;" it raises the lower, and the mulatto will be as satisfactory as the white parent—the higher type is dominant in the genetic sense. A host of observers will hold up their hands in astonishment at these entirely unproved and improbable assertions.

Instances of Fine Human Products of Negro-European Blends

But Professor Morselli proceeds as follows: "Too great a difference (among the parent races) proves always injurious to the descendants, as much in physique as in mind." This statement palpably contradicts the last, and no less contradicts the truth, for there are hosts of illustrations, such as Mr. Booker Washington, Mr. Dubois, and the late Mr. Coleridge-Taylor, who render the word "always" in our quotation simply preposterous. If anything were really known about the subject, no author could contradict himself and the evidence so flagrantly. Professor Morselli then proceeds with the following categorical assertions, which are indeed so comprehensive that no doubt the truth is to be found among them, but where?

"Mixed unions exert the same influences upon the mental characters of race as can be observed in bodily characters: (*a*) In the descendants will be found the same mixture of the capacities, aptitudes, and psychical tendencies of the parent races; (*b*) a combination may occur of the same characters with the formation of intermediate mental qualities; (*c*) there are sometimes

psychical racial qualities which become 'dominant' according to the well-known 'law of Mendel.'"

From this paragraph, which comprises almost all that the Eugenics Congress has to tell us upon the subject, it is evident that we still have everything to learn. It may be true that there are psychical racial qualities which are dominant to their opposites. If that be so, it is of extreme importance; but where is the evidence on the subject? Where, even, is the evidence that any particular "psychical racial quality" is in truth genetic, and not the result of the particular tradition and environment, especially during childhood and adolescence, of the race in question?

Conflicting Theories as to the Dominance of Fair or Dark

The only other paper at the English Congress which dealt at all with this subject was Mr. and Mrs. Whetham's, entitled "The Influence of Race on History," and from it we can confidently learn nothing whatever but that a tall and fair gentleman inclines to regard a tall and fair race as the really worthy and desirable element in the population of Europe. Mr. and Mrs. Whetham regard this Northern race, tall, long-skulled, blue-eyed, and fair-haired, as the salt of the earth—a conclusion which is the more easily reached by deliberately leaving the Jews out of account, together with any possible influence that Christianity may have had upon Europe. But, directly contrary to the views of Morselli, that the higher type asserts itself in the offspring, Mr. and Mrs. Whetham believe that the darker, shorter, more easy-going Mediterranean race asserts itself when these two are blended, and that the "Mendelian dominance" of its characters "would gradually efface the Northern characteristics as soon as intermarriage and unchecked social intercourse were permitted throughout the nation."

Do the Northern or Southern Races Best Endure the Conditions of Town Life?

Further, these authors believe that "the short, dark race can more easily adapt itself to a town life." So that the tendency towards urbanisation means the survival of these elements in our people rather than of the elements derived from the North. And here is the alarming conclusion: "It seems probable, then, that these modern tendencies of our civilisation favour selectively the racial elements of Southern origin, the elements that, as far as we can ascertain, have been the least productive of men of ability and genius in England. If this be the case, bearing in mind the characteristics of the two races, the British nation, and perhaps the nations of Western Europe generally, may find themselves becoming darker, shorter, less able to take and keep an initiative, less steadfast and persistent, and possibly more emotional, whether in government, science, or art."

As to all of this, it may be said with the utmost confidence that we know nothing whatever. The two authorities who dealt with the subject at the Eugenics Congress contradicted each other directly, neither of them adducing any evidence in favour of his view. There is no evidence that science can recognise, nor will there be any such until we have a series of studies of pedigrees really capable of elucidating the facts.

Meanwhile we have no better guide than common sense, and we must use it. There are all sorts of people in all races. No evidence exists to suggest that the offspring of good examples of diverse races have any natural disadvantage, if they be brought up under fair conditions. The founder of eugenics entertained no doubt upon the subject. In his "Hereditary Genius" he describes the best conditions, as he understands them, for the maintenance of a race.

The Best Conditions for the Growth of a Strong Race

"The best form of civilisation in respect to the improvement of the race would be one in which society was not costly; where incomes were chiefly derived from professional sources, and not much through inheritance; where every lad had a chance of showing his abilities, and, if highly gifted was enabled to achieve a first-class education and entrance into professional life, by the liberal help of the exhibitions and scholarships which he had gained in his early youth where marriage was held in as high honour as in ancient Jewish times; where the pride of race was encouraged (of course I do not refer to the nonsensical sentiment of the present day that goes under the name); where the weak could find a welcome and a refuge in celibate monasteries or sisterhoods; and lastly, where the better sort of emigrants and refugees from other lands were invited and welcomed, and their descendants naturalised."

Anyone who has looked into the record of the Huguenot stock since so many of its members made a home in England will see the meaning of this last clause. It may be accepted as reasonable and true until exact inquiry provides evidence to the contrary, which is excessively improbable.

THE WONDERFUL MILKY WAY

Unsolved Problems of Starland. Is Our Universe Boundless or Finite?

IS THERE AN UNREAD SCHEME OF STARS?

EVERYONE knows the Milky Way. It is one of the most striking sights of a clear night, for only on clear, moonless nights can we see its cloudy track of light across the heavens. More than any other celestial object it affects us with a sense of mystery and of unknown destiny—as, indeed, it has affected men at all times and in all countries. To the American Indian it was the "path of souls." In ancient mythology it had various meanings: thus, it was the highway of the gods to Olympus; or it sprang from the ears of corn dropped by Isis as she fled from her pursuer; or it marked the original course of the sun, which he later abandoned.

In mediæval times it became associated by pilgrims with their own journeys. Thus, in Germany, it was the "Jakobstrasse," or the road to the shrine of St. James at Compostella; in England, it was the "Walsingham Way," associated with the pilgrimages to the famous Norfolk shrine. There was nothing absurd or trivial in fancies of this kind; the pilgrim had no idea that his travels were the end and purpose of the Milky Way. He merely found it lying overhead, a mysterious path in the heavens; and his sense of universal unity led him in a child-like way to feel a deep association with it, and a sense of its intimate companionship. But this friendliness of the heavenly bodies, and the simple affection for them which we find in Chaucer and other mediæval poets, have been destroyed for most of us by the mere interposition of unimaginable distances.

The best times for seeing the Milky Way are in the evenings of autumn and winter; it is then high in the heavens, and thus suffers less from the interference of our atmosphere. It is then seen to stretch like a vast, ragged semicircle over the sky. Indeed, it traces a rough circle, for this line is continued over the southern hemisphere also. The circle is, however, very far from being smooth or even; the path is full of irregularities. It varies in width to an extent of about thirty degrees, and varies also considerably in brightness. Its total area has been estimated to cover rather less than one-fourth of the whole northern hemisphere of the sky, and to cover about one-third of the southern hemisphere. Its track lies through the constellations Cassiopeia and Auriga; it passes between the feet of Gemini and the horns of Taurus, through Orion just above the giant's club, and through the neck and shoulder of Monoceros. It passes above Sirius into Argo, here entering the southern hemisphere, and through Argo and the Southern Cross into the Centaur. In the Centaur the Milky Way divides into two streams, in a manner which suggests the divided course of a river around an island, a dark rift between the two luminous streams representing the island.

It is a very long island, however, for the double conformation of the Milky Way extends over one-third of its entire course—that is to say, one hundred and twenty degrees of the circle. The divergent branches reunite in the northern hemisphere in the constellation Cygnus. The brighter stream passes through Norma, Ara, Scorpio, and Sagittarius; along the bow of Sagittarius into Antinous, here entering the northern hemisphere again; then through Aquila, Sagitta, and Vulpecula it arrives at Cygnus and reunion with the branch which left it in Centaur. From Cygnus the stream, now single, passes through Lacerta and the head of Cepheus to the point whence we started, in Cassiopeia.

As we follow the Milky Way throughout its course, we find it continually sending out streaming appendages of nebulous appearance towards clusters, nebulæ, or groups of stars. In Norma it sends out a complicated

series of nebulous streaks and patches, covering the Scorpion's tail, spreading faintly over the leg of Ophiuchus, and extending beyond, as if to meet a corresponding branch sent off from the region of Cygnus in the northern hemisphere. The latter is a very bright and remarkable streak, running south through Cygnus and Aquila, to become lost in a dim and sparsely starred region. From Cassiopeia a vivid branch proceeds to the chief star of Perseus, and faint streaks appear to continue the "feeler" towards the Hyades and the Pleiades. There are many other "feelers" of the same kind, and they are all of great interest, because they seem to show some sort of influence exercised by the Milky Way upon the whole sidereal universe.

Proofs of the Dominating Position Held by the Milky Way

But there are other indications, also, that the Galaxy holds a dominating position. For example, the Milky Way seems to determine very directly the groupings of various bodies in the heavens. The regions through which it passes are the exclusive habitat of certain classes, while other classes as consistently avoid it. Thus the gaseous nebulæ are almost all in or close to the path of the Milky Way, but the "white" nebulæ, on the contrary, congregate at a distance from it. Globular clusters, again, are found in very large numbers within it; in fact, a continuous line of star-clusters lies along its centre for a considerable part of its course, forty out of about a hundred known clusters being within this zone. This marked preference of clusters for the region of the Milky Way is worthy of notice, because of the suggested relation between globular clusters and the white nebulæ, which avoid that region. "New" stars appear to belong only to the Milky Way, so that we may suppose that the conditions which are needed to make a dark star flash out into temporary glory exist only here. Red stars, gaseous stars, and short-period variables display also a preference for the region of the Galaxy.

Ancient and Modern Conceptions of the Nature of the Milky Way

Strange theories as to the nature of the Milky Way have been put forward at various times. Anaxagoras thought it might be due to the shadow of our globe; Aristotle, that it was some kind of mist due to the exhalation of vapours from the earth.

But a grander and truer conception of its nature and situation, removed far from the earth and independent of any terrestrial cause, had early come to several minds. Pythagoras and Democritus both formed the conjecture that its shimmer might be due to innumerable stars, and in 1610 Galileo's telescope confirmed their theory.

As we have seen, the Milky Way is by no means a simple stream of stars; with careful observation, even the naked eye can perceive something of its irregular detail, when the atmosphere is unusually clear, and there is no moon. Viewed under these conditions through a good telescope, the effect of the Milky Way, when made to pass progressively before the vision, is one of unexampled grandeur and sublimity.

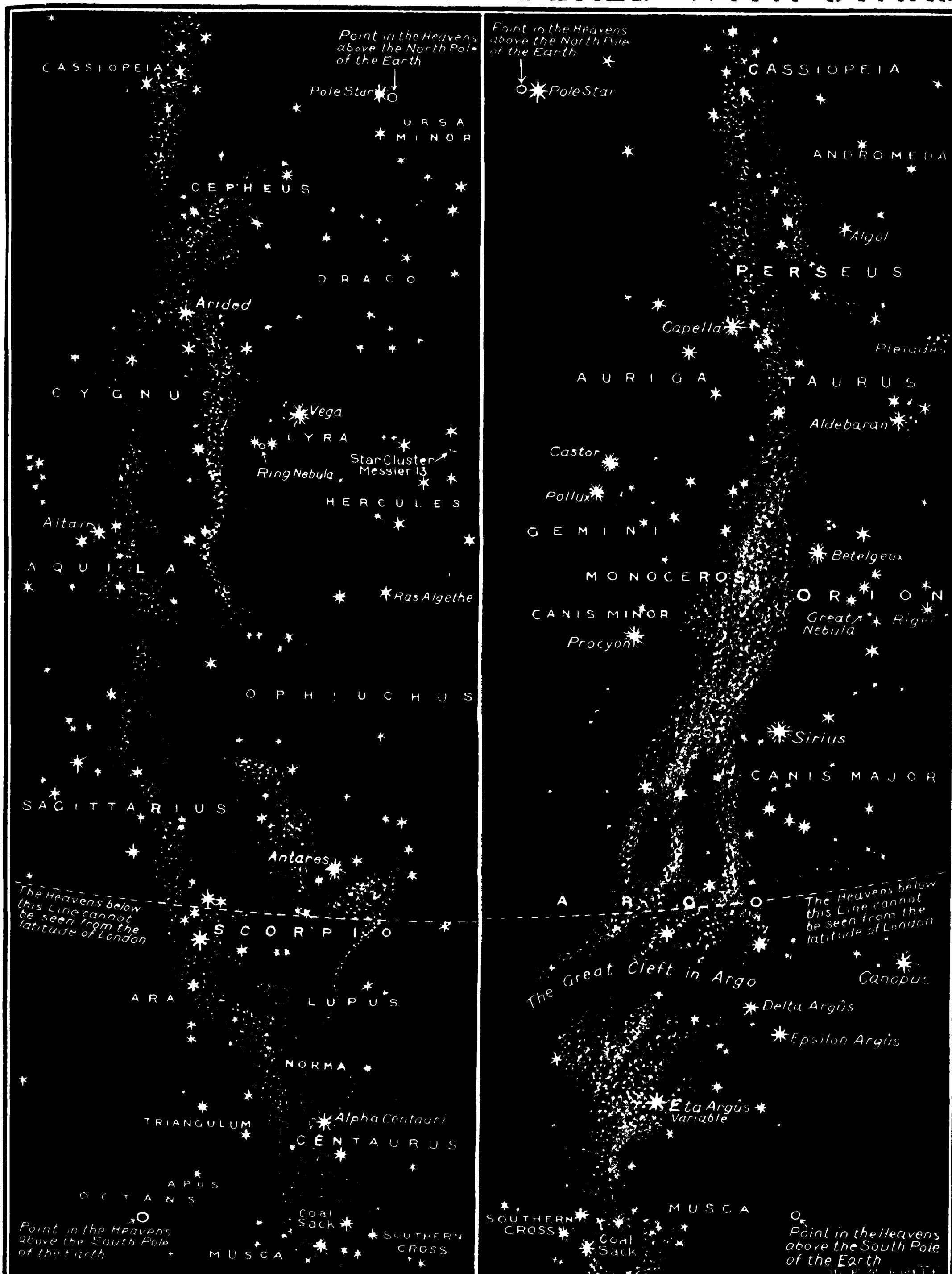
The general effect has been well likened to that of an old, gnarled tree-trunk, marked with knots and curving lines, and riddled with dark holes and passages, linked together by shimmering wisps or arches. This general effect is practically lost as the detail becomes clear in a telescopic view. The detail is extremely various. At one point it may consist of separate stars scattered irregularly upon a background of darkness; at another, of star-clusters, sometimes following one upon another in long, processional line; at another, the stars seem to collect in small, soft clouds, presenting the appearance, as the telescope sweeps over them, of drifting foam.

The Strange, Dark Rifts in the Skyscape Where no Stars Appear

At yet another point the track may be involved in nebulosity in which many stars appear to be imbedded. Perhaps the most characteristic features are several which have already been remarked as conspicuous in star-clusters or nebulæ, such as lines of stars, dark lanes or rifts, and dark holes. The lines of stars, which are evidently connected by some actual physical relation, are either straight, curved, radiated, or in parallels. In Sagittarius is a very striking collection of about thirty stars resembling in form a forked twig with a curved hook at the unforked end. The dark rifts in the Milky Way show the same features as those in star-clusters. Sometimes they are parallel; sometimes they radiate like branches from a common centre; sometimes they are lined with bright stars; sometimes they are quite black, as if utterly void; sometimes slightly luminous, as if powdered with small stars.

Large, dark openings, resembling the Keyhole and other apertures in nebulæ, are very frequent. The most famous of these is the Coal-sack, which occurs close to the constellation of the Southern Cross. Soon after

A CIRCLING ZONE POWDERED WITH STARS



THE PATH OF THE MILKY WAY THROUGH THE HEAVENS, SHOWING THE NEIGHBOURING STARS

The Milky Way, when seen from the earth, appears as a great ring of stars. These two drawings show the two semi-circles of the Milky Way as they extend from the region of the Polar Star to the region of the Southern Cross on each side of the apparent sphere of the heavens. It will be noticed that the bright stars congregate near its region, and that there is a characteristic harmony in the way in which the wisps appear to project into space, suggesting some common cause for this appearance throughout the whole galaxy.

the southern reunion of its two branches in the Centaur, the Milky Way broadens and appears studded with a collection of brilliant stars, so that this is one of the most resplendent areas in its whole course. Right in the centre of this host of bright stars, and close to the four chief stars forming the Cross, is a pear-shaped cavern, blackly dark. This apparent opening into the great void is known as the Coal-sack. Many attempts have been made to explain away this phenomenon as an optical effect, but all these attempts have been ludicrously inadequate. The sharp distinction of its outlines, its huge size, its utter darkness, and the even brightness of the starry edge surrounding it, make it impossible to explain the Coal-sack as an optical effect. It must be very much what it seems—a huge cavity in the masses of bright stars. It is by no means unique; there are a great many similar black holes, generally less clearly defined and less striking in appearance, but manifestly of similar origin. Mr. Barnard describes one of these, in Sagittarius, as "a most remarkable, small, inky-black hole in a crowded part of the Milky Way, about two minutes in diameter, slightly triangular, with a bright orange star on its north preceding (north-westerly) border, and a beautiful little cluster following." Here, again, a dark vacuity is found in conjunction with a number of bright stars.

Has Some Disintegrating Force Been at Work in Expanses of the Heavens?

Another very striking irregularity is the Great Break in Argo, which occurs shortly after the Coal-sack. After its expansion in the Southern Cross the stream of the Milky Way narrows, but spreads out fan-wise in Argo; and here, at its widest part, it is cut sheer across by a dark chasm. On either side of this Great Break the stream sends out finger-like branches of faint light, as if attempting to reach across, the branches on opposite sides of the Break being in obvious correlation. The appearance of a once-united stream rent asunder by some great force is very strongly suggested by this chasm. The dark rifts and chasms of the Milky Way, like those of star-clusters, point to the presence within this vast structure of some disintegrating force, which may eventually result in its entire dissolution.

The nebulous wisps and feelers which the Galaxy throws out towards stars, constellations, or nebulæ are very interesting. Tenuous feelers of this kind reach, or very nearly reach, among others, the Hyades, the Pleiades, Præsepe, Orion's left shoulder, and the Pole Star.

But a still more interesting fact has been discovered with regard to the relation of the Milky Way with all the other stars of the heavens. It is that, on the whole, the stars tend to increase in number gradually and in regular order toward the region of the Milky Way. According to Sir William Herschel, the distribution of stars is thirty times more dense at the equator than at the Poles of the Milky Way. This law of galactic crowding has been traced further in remarkable detail by later investigators, and it has been found that a similar progressive crowding marks the distribution of the stars belonging to each individual magnitude.

Is There a Meaning in the Crowding Together of the Most Brilliant Stars?

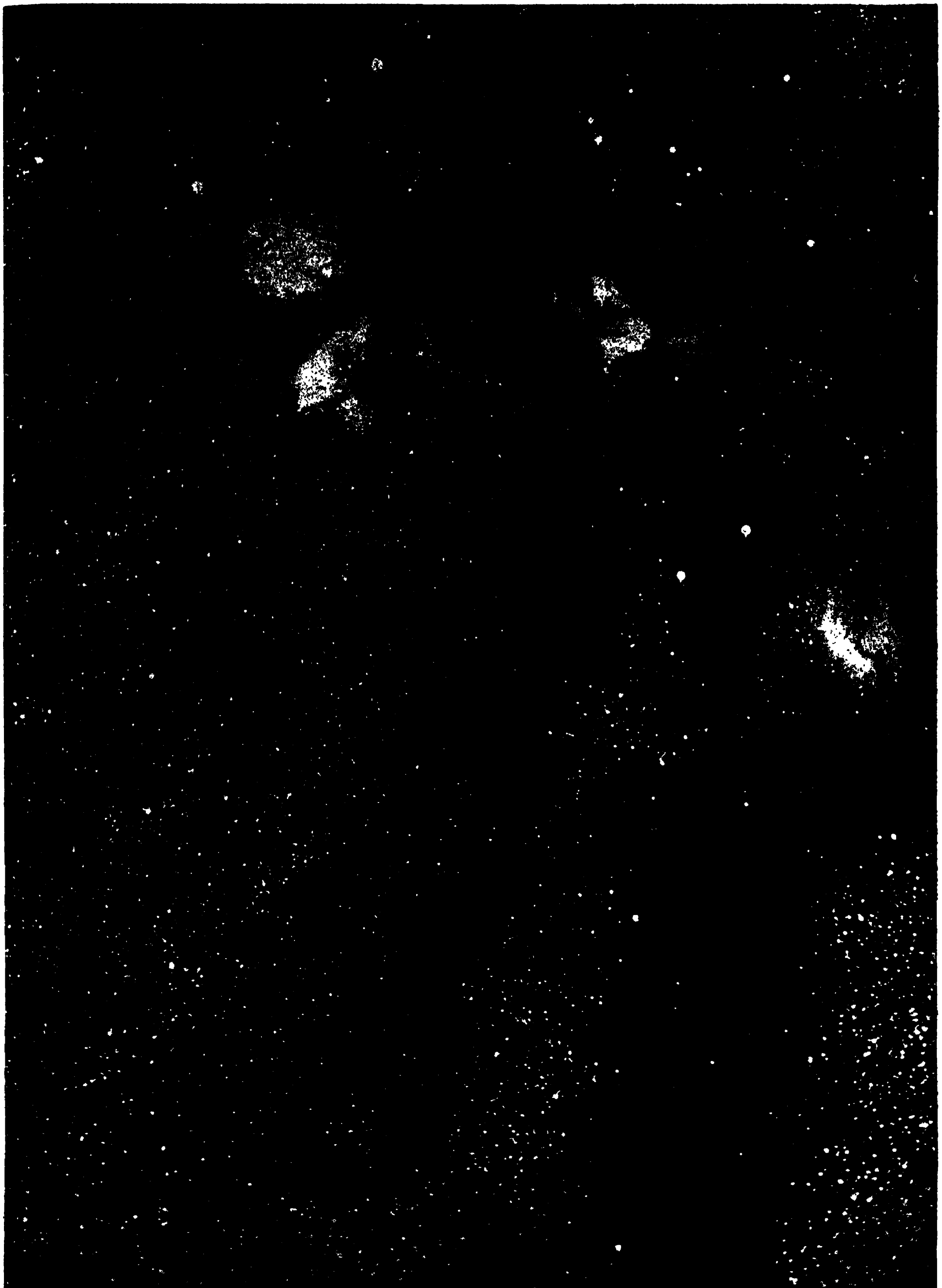
This is well exemplified, for instance, in the positions of the ten most brilliant northern stars. Three of these—Capella (in Auriga), Altair (in Aquila), and Deneb (in Cygnus)—stand almost upon the central line of the Milky Way; while four more—Vega (in Lyra), Procyon (the lesser Dog-Star), Betelgeux (in Orion), and Aldebaran (in Taurus)—are either just within or upon its borders. Only two out of the ten—Regulus and Arcturus—are at any considerable distance from the Milky Way. Yet, in proportion as the stars diminish in brilliance, their crowding toward the galactic zone becomes less and less marked, until it can barely be perceived in the case of stars which are only just visible to the naked eye. In the first ranks of telescopic stars—that is to say, about the seventh magnitude—there is hardly any of this crowding, but in magnitudes below this it is again progressively evident.

Evidence of a General Plan of Construction in the Heavens

This regular and conspicuous law is almost conclusive evidence of a general plan of construction in the heavens, in which the Milky Way is intimately involved and in some way dominant. A further proof of this dominance is supplied by the grouping of the nebulæ in the sky, for they form a striking contrast, or complement, to the grouping of the stars.

Two great zones in which white nebulæ are condensed are clearly apparent, and a map (see page 1501), showing both these areas and the path of the Milky Way, is very instructive. A large zone, with the Milky Way as its central line, is almost clear of nebulæ, which congregate as two great

"THE EARTH WAS VOID & WITHOUT FORM"



A PART OF THE NEBULA OF RHO OPHIUCHI, SHOWING DARK LANES
From a photograph taken by Mr. E. E. Barnard at the Mount Wilson Observatory

canopies hanging about the galactic Poles. This accumulation of nebulæ towards the Pole is particularly marked in the northern hemisphere; in the southern hemisphere, although the same principle prevails, there is less concentration, and the nebulæ appear more evenly dotted over the sky. The wide zone, which is avoided by white nebulæ, about the entire circle of the Milky Way, is very pronounced. Over gaseous nebulæ, on the contrary, the Milky Way exercises not a repellent but an attractive influence, just as it does over stars and star-clusters.

The Curious Avoidance of Each Other by Stars and Nebulæ

The study of the Milky Way emphasises very strongly the "relation of avoidance" between stars and nebulæ. The apparent law was well summed up by Herbert Spencer as long ago as 1854: "In that zone of celestial space where stars are excessively abundant, nebulæ are rare; while in the two opposite celestial spaces, that are furthest removed from this zone, nebulæ are abundant. Scarcely any nebulæ lie near the galactic circle; and the great mass of them lie round the galactic poles. Can this be mere coincidence? When to the fact that the general mass of nebulæ are antithetical in position to the general mass of stars we add the fact that local regions of nebulæ are regions where stars are scarce, and the further fact that single nebulæ are habitually found in comparatively starless spots, does not the proof of a physical connection become overwhelming?"

The Sublime Constructive Scheme that Baffles Human Research

It is impossible to contemplate the vast system of the Milky Way, and the incontrovertible evidences of its intimate and far-reaching connection with the distribution of the heavenly bodies outside its own system, without speculating as to the nature of these relations, and as to their possible indication of some vast scheme of construction in the entire heavens. The knowledge of stellar varieties, of the violet-white Sirian and of solar stars and of all the other kinds, and our knowledge of the marvellous movements, variations, and systemic relations of stars, expand and deepen the glory and mystery of the heavens. The sense of some vast, undiscovered plan comprehending the movements and relations of all is altogether in keeping with the sublimity with which the night sky impresses everyone. But when we review the attempts to construct this scheme we are baffled by a sense of their futility and artificiality.

Sir William Herschel's "disc theory" was for many years generally accepted as a credible explanation of the distribution of the stars in the heavens. This theory had already been put forward, thirty years earlier, in 1750, by Thomas Wright, of Durham, but Herschel adopted and strengthened it by applying to it his method of "star-gauging." Starting from the hypothesis that the stars are actually, on a broad average, evenly distributed in the heavens, he ascribed the appearances of concentration and of wide scattering to optical effects; and was thus led to conceive of the heavens as a vast system of stars evenly distributed in a form roughly resembling a grindstone, the solar system being situated near the centre of this grindstone, and the Milky Way representing an enormous depth of stars included in our view along the plane of the disc. The actual figure which Herschel deduced from his laborious plumbing of the star-depths was an irregular disc, cloven at one end, the cleavage representing the bifurcated part of the Milky Way.

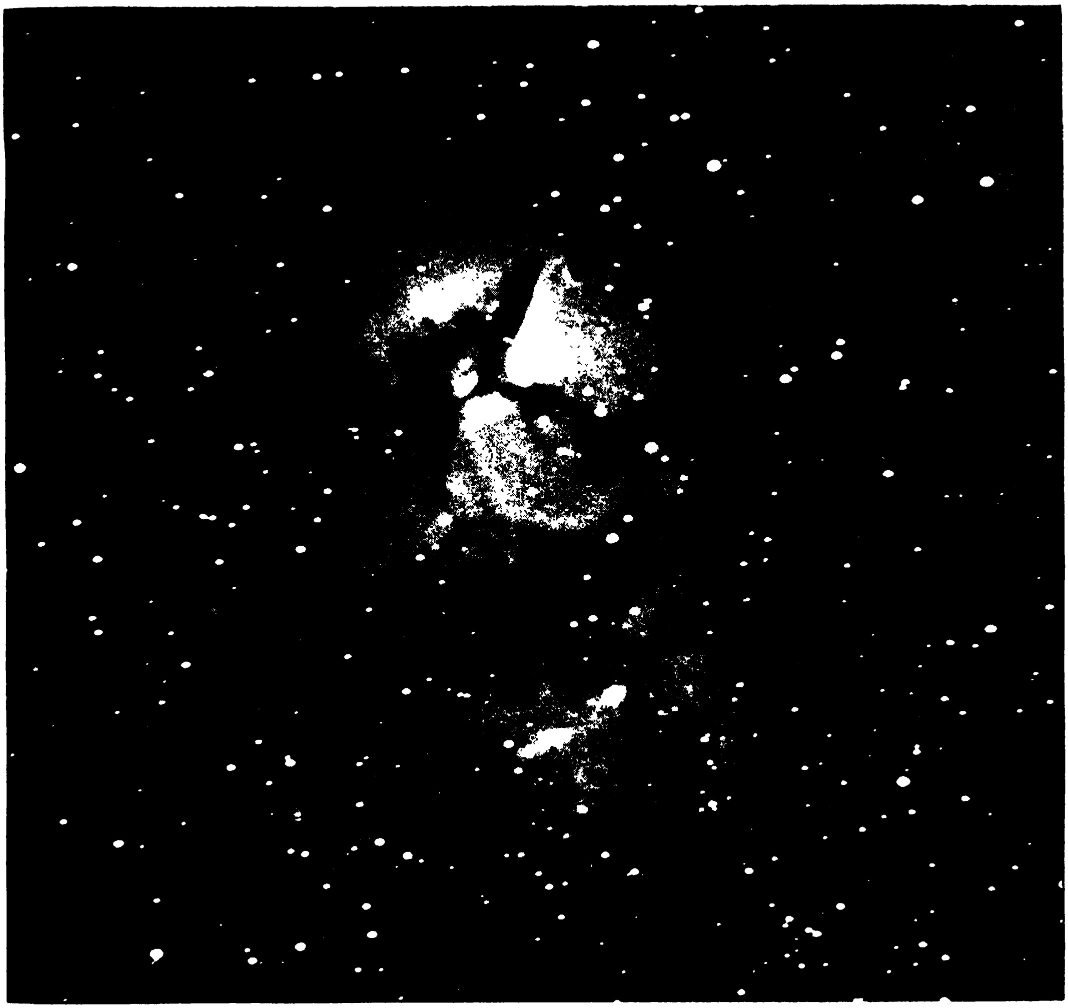
Rejected Guesses at the Architecture of the Eternal Temple

But this theory requires quite incredible assumptions in order to explain such appearances as the Coal-sack and other features of the Milky Way. The Coal-sack and other black holes could only be explained by imagining vast conical tunnels through the whole stratum of stars, all converging directly upon the solar system, while stellar groups of exceptional richness would require for their explanation as optical effects the assumption of columns of stars of tremendous length stretching out from the edge of the disc away into space. Explanations of this kind are too fanciful. It is more satisfactory to accept the appearances as corresponding to reality, and to reject the hypothesis of the even distribution of all the stars.

Indeed, Herschel himself came later to this conclusion, and tacitly rejected his own theory of a disc-like sidereal system. The result of his star-gauging labours was eventually to demonstrate real inequalities of distribution. In 1802 he was able to say that "the Milky Way is by no means uniform. The stars of which it is composed are very unequally scattered, and show evident marks of clustering together into many separate allotments." Yet, notwithstanding this repudiation, the disc theory was for years afterwards accepted with all the authority of Herschel's name.

Sir John Herschel, who continued to gauge the star-depths in his father's manner, realised that the Milky Way must be a definite structure, and not a mere effect of the heavenly bodies in general due to our position among them. But he still conceived that the situation of our solar system was the most important factor in producing the appearances under which we see the Galaxy. He cut away, as it were, the centre from the disc, and left the Milky Way as a flattened ring which we see edgewise from our position within its hollowed centre. But this theory leaves almost all the difficulties intact. Appearances such as the Coal-sack and the Great Break in Argo require an equally elaborate and artificial hypothesis to explain them under the conception of a ring as under that of a disc, if the ring be held to consist of evenly distributed stars seen in various positions and groupings, and looking thick simply because we regard the ring edgewise.

Any theory which regards the Milky Way as entirely or even chiefly an optical effect has to meet an insuperable difficulty in the definite outlines of the stream itself—at least over the larger part of its course. If the concentration of stars were an optical effect it would almost inevitably be much more gradual, so that there would be no sharp limit to the Milky Way. But its outline is so well defined that in some parts one photographic plate may show one half within

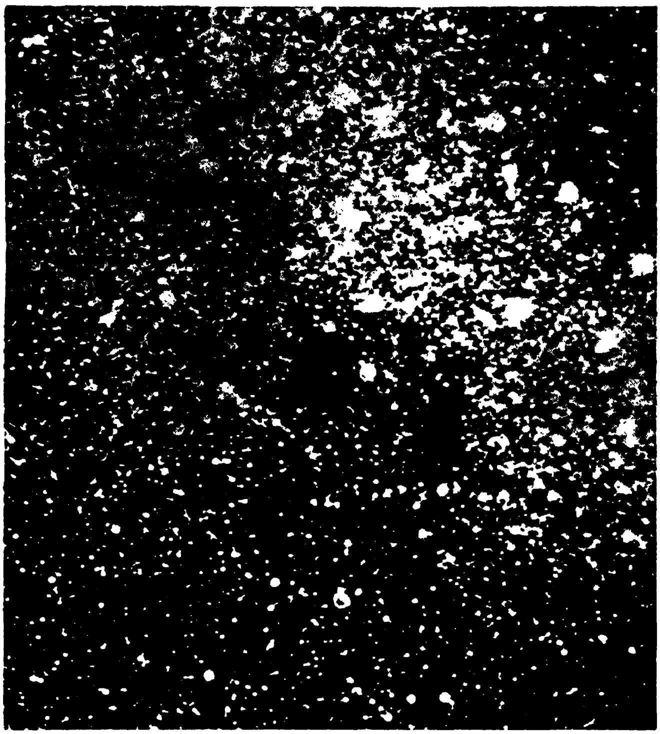


THE TRIFID NEBULA IN SAGITTARIUS, SHOWING ITS DARK RIFTS

From a photograph taken at the Lick Observatory

its borders and the other clearly without, thus including two regions of contrasted character.

The wide prevalence of the principle of spirality throughout the whole range of heavenly bodies has led to various recent theories, which trace in the general conformation of the Milky Way double or quadruple spiral branches, so disposed to our view as to produce the effect of the stream which we have traced. About the middle of the last century a theory of this kind was brought forward by Stephen Alexander, of New Jersey, who traced the evolution of the celestial universe back to a great spheroidal configuration, and saw in the Milky Way the surviving streams which issued from it, and flowed in four spirally winding currents. The idea of the whole known universe as having originally been one vast spheroid, of which the Milky Way perhaps still marks the equator and the collections of white nebulæ mark the Poles, is generally accepted as providing a credible and trustworthy statement of fact. It corresponds with the principles which are found to be universal, or nearly universal, in the heavens. The spiral principle is one of the most general of all these. As we have seen, all nebulæ, with very few possible exceptions, can be finally resolved into spirals; and the close analogy of the Milky Way with nebulæ has already been discussed (see page 1502). The difficulties which the Coal-sack, the Great Break, and other remarkable features of the Milky Way present to any other theory do not affect the nebular theory. Similar features characterise many of the great nebulæ, such as the black cavern of the Keyhole, the dark rifts of the Trifid nebula, and the lines or groups of bright stars, or single stars, significantly placed in relation to these dark areas. It is possible, however, to be too confident in attributing the appearance of the Milky Way to a vast spiral structure, because with increasing knowledge this starry stream may be explained on some other principle.



A STAR-CLOUD IN SAGITTARIUS, WITH A DARK ABYSS WITHIN IT, CONTAINING BUT A SINGLE STAR

From a photograph by Mr. E. E. Barnard

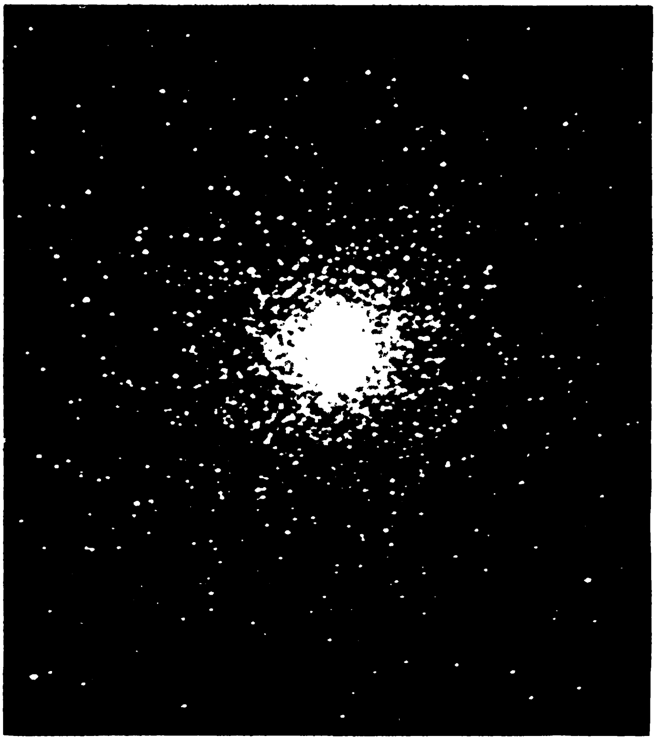
In the meantime our knowledge of it is so incomplete that it is safest, and very likely most true, to regard the Milky Way as actually corresponding in structure with the appearance under which we see it. That is to say, it is probably a huge, irregular ring, collecting within its vast system an endless variety of bodies and separate systems of stars, clusters, and nebulæ, and throwing out branches and "feelers" in all directions, over enormous distances. Some of these structures, of course must be very much nearer to us than others because projected towards us, yet seen upon the same visual zone. The influence of the Milky Way is apparently predominant, both in the way of attraction, as in the case of star-clusters, and in the way of rejection, as in the case of white nebulæ. Any further conjectures with regard to its physical conformation or to the nature of its influence are as yet premature. The study is all the more difficult because it has so far been found impossible to secure any definite knowledge as to the actual distance from us of the Milky Way or of any of its parts.

Certain upward and downward limits of distance may, however, be estimated with

some degree of probability. There is in existence a catalogue of stars, from the first down to the tenth magnitude, which may be regarded, for all practical purposes, as complete. Comparing the numbers of stars of each successive magnitude, as derived from this list, they are found to increase in a regular ratio corresponding to the increase in available space. If we presume magnitude to be, over a sufficiently wide average, a safe criterion of distance, we should expect to find the stars of each magnitude progressively more numerous than the stars of the magnitude before it. For as distance increases, so does the available space, for the spaces at successive distances are contained by larger and larger spheres, with our system as centre.

If, then, on a broad average, the stars are equally numerous at all distances, we should expect the number of stars of each magnitude to bear a regular ratio to the number of the magnitude before it; and this ratio ought to be very nearly as four to one. Now, from the first to the ninth magnitudes, the numbers of the stars do, in fact, increase in this proportion; or, rather, they do so nearly enough to exclude the idea of any such addition as would be the result of the presence, within the sphere marked by the ninth magnitude, of the host of stars contained in the Milky Way. It has been concluded, therefore, that the stars forming the Milky Way do not occur within the distance of ninth-magnitude stars. This apparently gives us a lower limit to the possible distance of the Milky Way. The higher limit is less easily determined. It seems clear, however, from Herschel's surveys, that this regular increase in the numbers of stars at successive magnitudes does not continue to an indefinite extent. At some point, not clearly known, between the tenth and fourteenth magnitudes, the increase ceases, and the numbers of stars at successive magnitudes begin to diminish instead; so that by the time we come to fourteenth-magnitude stars we find that they are sparsely scattered in the heavens. Somewhere in this interval, therefore, the myriad stars of the Milky Way are probably to be found.

The fact of this thinning out of stars below a certain magnitude is borne out not only by Herschel's soundings, but also by the recent researches of Professor Pickering and others. It strongly confirms the assumption that the sidereal system, though inconceivably vast, is yet not infinite, but finite. This assumption is generally based on the argument that from an infinite universe of stars we should receive also an infinite amount of light, the increase in numbers making up, at each successive step in remoteness, for the diminishing amount of light received from each star The argument, of course, takes for granted the universal prevalence of the law that light does not suffer diminution as it travels through space—does not, so to speak, at last go out. If this law fails in any part of the universe, the darkness of the background of the sky cannot be taken to prove the finitude of the celestial host. But no evidence exists of the cessation of light.

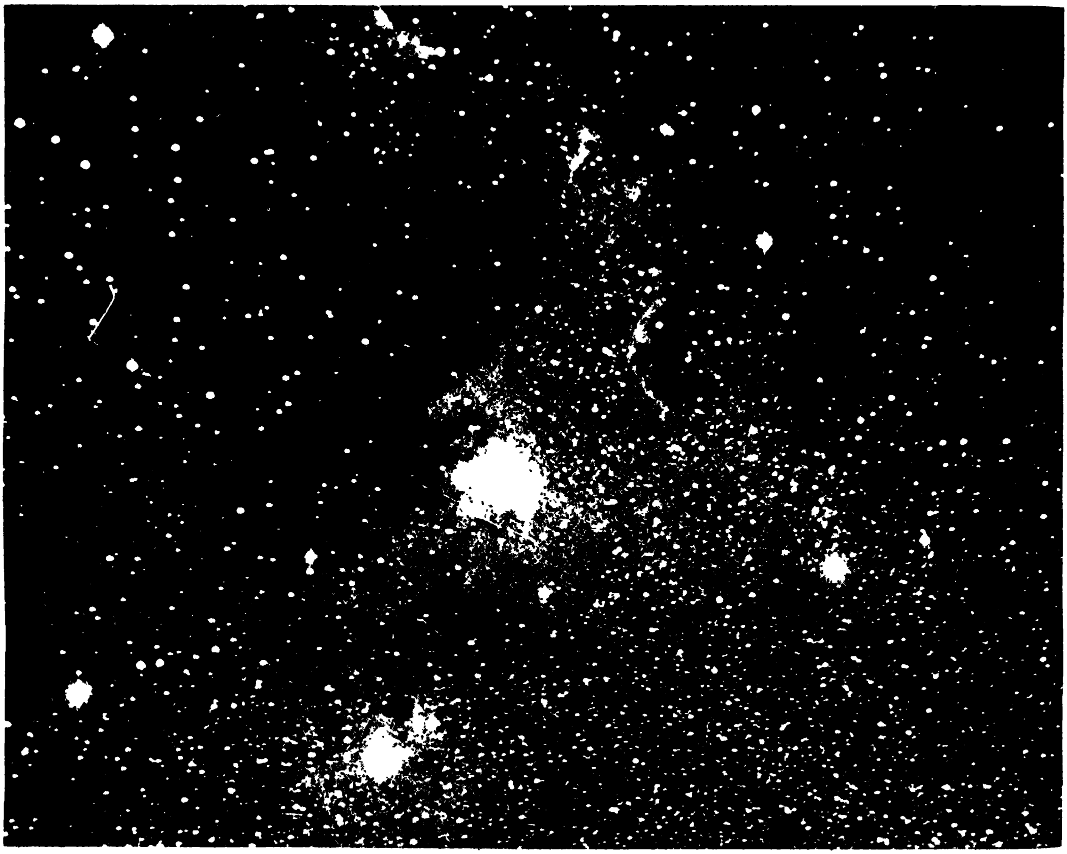

THE MAGNIFICENT STAR-CLUSTER MESSIER 13 IN HERCULES
From a photograph taken at the Lick Observatory

The deviations from the due ratio of the numbers of stars in the several magnitudes have disclosed certain significant facts.

It has been found that the numbers of the stars of the first four magnitudes are in marked excess to the theoretically correct numbers; but that if about five hundred be deducted from the number of stars of these four magnitudes, the whole series, from the first magnitude to the ninth, presents a fairly close reproduction of the series of numbers which we should expect according to the theory of ratio. Secondly, it is a striking fact that about five hundred bright stars have been observed to form a clearly defined belt, in the nature of a much smaller circle than the Milky Way, but apparently in some relation to it. It has been suggested, with great probability, that the five hundred stars are in each case the same. This stream of bright stars is not far removed from parallelism with the Milky Way, making with it an angle of about twenty degrees, and crossing its path in the Southern Cross and in Cassiopeia. Many believe that this stream or belt of bright stars represents a great star-cluster, of which our sun is a member. If this conjecture be correct, the solar motion which appears to be directed at present towards the constellations of Hercules and Lyra must be a secondary or subordinate motion, swinging around the centre of gravity of this cluster, and not a primary motion among the whole host of heaven; for the supposed motion of the sun in space has been determined chiefly by reference to some of the bright stars of this cluster.

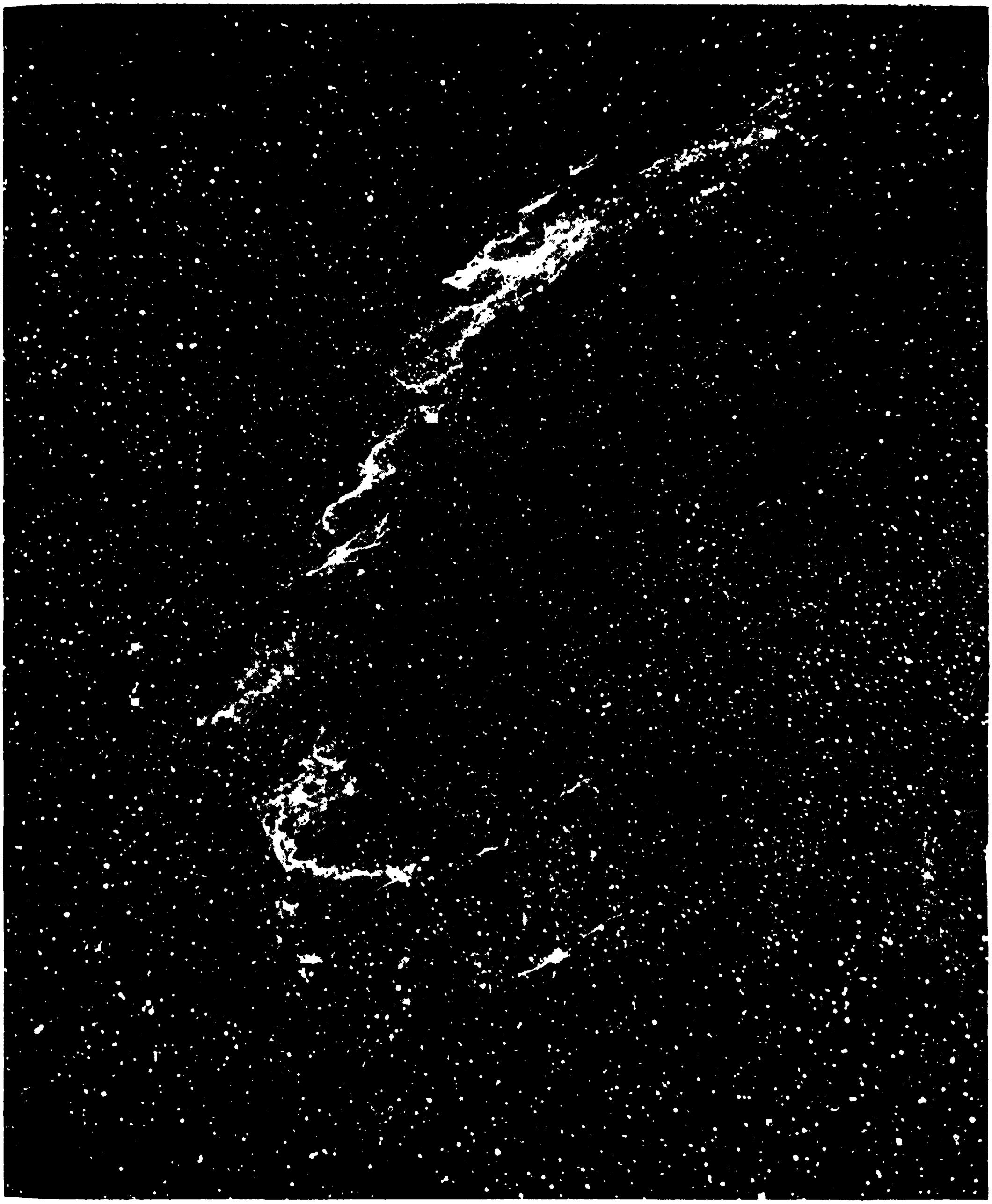
There are, however, some difficulties in defining this supposed cluster of suns. Many of the five hundred bright stars forming the belt belong apparently also to the system of the Milky Way. Is the solar cluster, then, involved in some manner in the stream of the Milky Way? Or are these five hundred stars to be excluded from the Galaxy? No certain answer can as yet be given to these questions, which demand much careful study of the relative movements of the stars involved.

The actual construction of the heavens



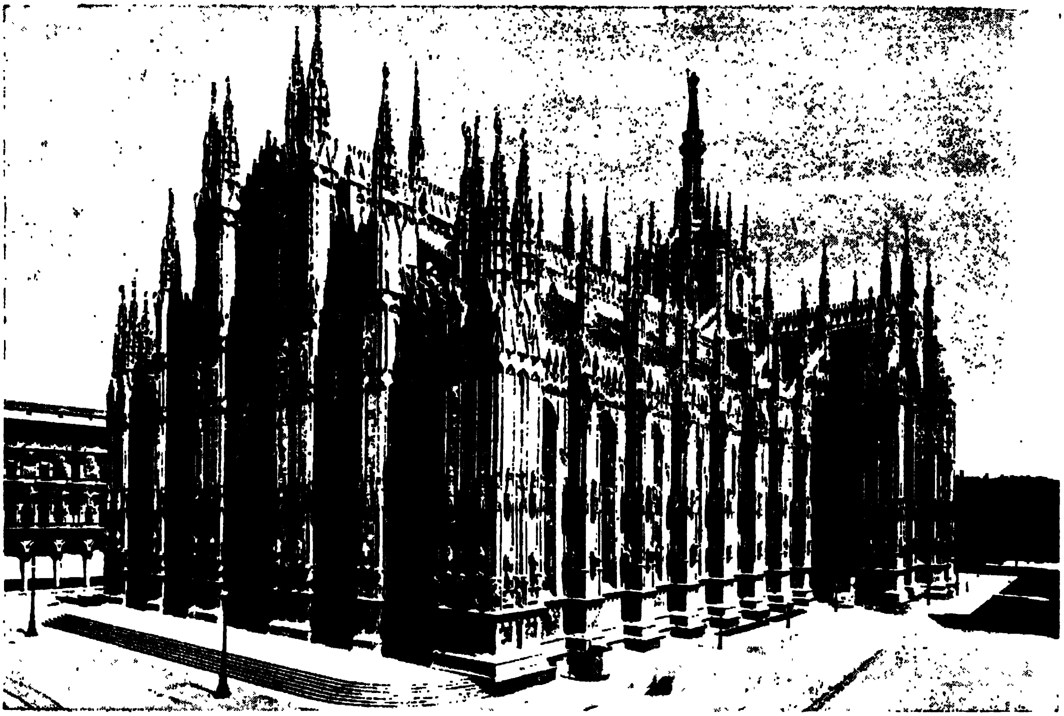
THE STRANGE SHAPE OF THE MAGNIFICENT H. V 37 NEBULA IN CYGNUS
From a photograph by Mr. Isaac Roberts

remains a supreme mystery. We cannot tell with any certainty whether the starry universe is of finite or of infinite extent, nor read the architectural plan which determines the positions and the motions of the stars. We must remember always that our view of the heavens is strangely composite; it is a table of records of all ages appearing simultaneously upon the background of unfathomable space. Written upon it we see every gradation of form, from nebula to star, and through all the phases of stellar luminosity to extinction. And in all probability the dark bodies, which we shall never see, far outnumber the myriads of stars.

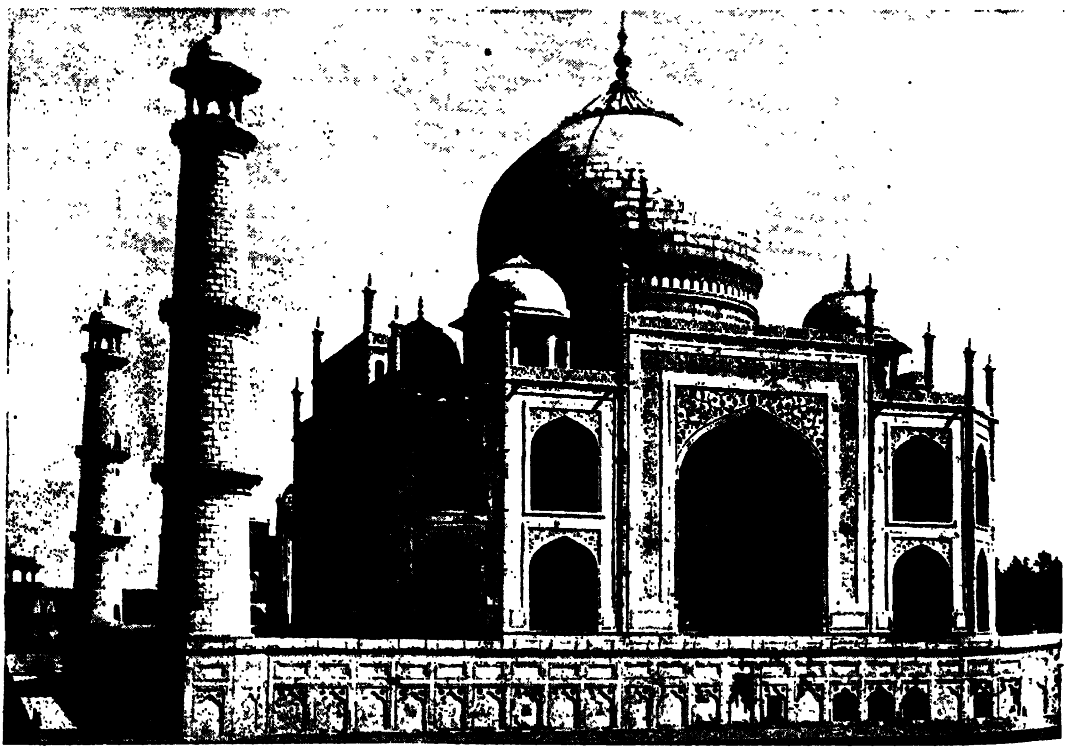


A BEAUTIFUL WISP OF NEBULOUS MATTER IN CYGNUS

From a photograph taken at the Yerkes Observatory



MILAN CATHEDRAL, A MARBLE MASTERPIECE OF THE WEST



THE TAJ MAHAL, A MARBLE ARCHITECTURAL GLORY OF THE EAST

THE FUTURE OF THE EARTH

Conjectures as to What May Happen to the Solar System in an Illimitable Hereafter

THE PAST THE PROMISE OF WHAT SHALL BE

THE Future is contained in the Past, as a rose is contained in its seed, and the more knowledge we have of the earth's past, the more prescience we shall have of the earth's future. We have looked into the "dark backward and abysm of time," and have had glimpses of the making of the earth. We have seen it hurled from the fringe of a revolving nebula, or compacted by the fiery clashing of a swarm of meteorites. We have watched its metallic ocean lifted into surges by the sun; we have beheld the moon torn from its side. We have seen the water-vapour condense into steaming oceans, and from the oozy ocean-floor we have seen the Alps and Himalayas rise. We have read in the fossils many chapters of earth's ancient history; we have wandered under the lepidodendrons in the ferny forests of the Carboniferous period; we have chased the mammoth over the glaciers of France. Everywhere we have found change—changing continents, changing mountains, changing rivers, changing seas. We have found that no continent can survive the erosion of river and rain for more than a few million years, and that there is no ocean that may not have new islands and new continents in its womb. Trees and flowers, birds and beasts, cities and caravanserai, pass away "like snow upon the desert's dusty face." Where are now the pterodactyls and ichthyosaurs, and dinosaurs? Where are now Babylon and Nineveh? Well might Francis Thompson magnificently apostrophise the earth:

Thou hast devoured mammoth and mastodon,
And many a floating bank of fangs,
The scaly scourges of thy primal brine
And the tower-crested plesiosaur.
Thou fill'st thy mouth with nations, gorgest slow
On purple æons of kings; man's hulking towers
Are carcase for thee and to modern sun
Disglutt'st their splintered bones.
Rabble of Pharaoh's Arsacidæ
Keep their cold house within thee; thou hast sucked down
How many Ninevehs, and Hecatompyloi,
And perished cities whose great phantasmata
O'erbrow the silent citizens of Dis.

Birth and death, death and birth, constant change, that has been the past history of the earth. And still death and birth are busy, and "the great world spins for ever down the ringing grooves of change."

What is still to come? Can we foresee? Very little can be definitely and certainly foreseen, and we cannot foresee very far. We know that the rivers will continue their work of destruction. We know that the mud plastered on the oozy sea-floor may be the marble of future mountains, from which may arise the man-wrought glories of a Milan Cathedral or a Taj Mahal. We know that round the margins of the continents there will probably be subsidences and elevations as heretofore, and we know that it is even possible that the abysmal deeps with their sharks' teeth and whales' bones may yet be heaved into the air from "the whales to the eagle skies." It is possible, too, that the coral-crowned volcanoes in the Pacific are the vanguard of a new continent. These things we foresee and surmise, but our prescience is very vague and provisional, and we cannot foresee with certainty or foresee far ahead. Nor can we foretell the ultimate end of these physiographical changes. Some day, probably, all changes will cease; some day, probably, the final mountains will look upon the final seas, but what shape or position mountains and sea will have we do not know.

We say probably all changes will cease. Why? They will cease because, probably, the mainspring of the world's energies will some day run down. The mainspring of the

world's mechanism is multifold; it includes the earth's own rotatory and revolutionary energy, its own internal heat, and the heat of the sun. On the heat of the sun the world's changeful physiographic career largely depends. We receive less than one two-thousand-millionth of the sun's heat, yet that small dole of solar energy suffices to do wonderful things.

The Changing of the Earth's Warmth from Inside to Outside

At first the earth's physiography depended to a great extent on its own vital heat. With its own vital heat it boiled and bubbled; with its own vital heat it raised the rain, but after a time it cooled to 1200° Centigrade, and acquired a more or less solid and stolid crust; and then it cooled to 370° Centigrade, and acquired a steaming ocean; and now it has cooled still further, until in many ways the heat inside it is less important than the solar heat outside it.

"The sun," says Helmholtz, "drives on earth a kind of steam-engine whose performances are far greater than those of artificially constructed machines. The circulation of water in the atmosphere raises, as has been said, the water evaporated from the warm tropical seas to the mountain heights; it is, as it were, a water-raising engine of the most magnificent kind, with whose powers no artificial machine can be even distantly compared."

This water-raising engine it is that wears away the mountains, and lays the sediment for future continents on the bottom of the sea; this water-raising engine it is that makes the trades and the anti-trades, and all that they imply. It is the sun that hammers the carbon of the air into the tissues of the plant; it is the sun that waters the cornfields of the world.

The Great Counteracting Forces of the Sun and the Earth

It is true that earth-power complements sun-power. The sun raises the water, and the earth pulls it down again; the sun raises the anti-trades, and the motion of the earth gives them force and obliquity; the sun lays down the sediment, the earth crumples it into mountains; the sun hammers the carbon into the plant, but earth supplies the iron and the chlorophyll. Still, the sun is potent, the sun is essential.

How long, then, can the sun last? How long can this mighty water-raising engine continue to raise water? Not so long ago it was thought that the sun had only a few thousand years to live, and must soon burn out. Not so long ago Professor Tait declared that in 5000 years the sun would be a cinder. "Take," he said, "in mass equal to the sun's mass, the most energetic chemicals known to us, and in proper proportion for giving the greatest amount of heat by actual chemical combination, and, so far as we yet know their properties, we cannot see the means of supplying the sun's present waste for even 5000 years."

Not till Helmholtz showed that the sun's heat must be mainly a product of contraction did the sun seem to have many years before it. The sun's diameter contracts about sixteen inches every day, or about a mile every eleven years, or about 170 miles since the beginning of the Christian era; and Helmholtz calculated that this contraction alone is sufficient to supply all the heat that radiates from the sun. Allowing for this source of heat, and assuming that the sun will continue to contract till it is as dense as the earth, he came to the conclusion that there would be sufficient heat developed "to maintain for an additional 17,000,000 years the same intensity of sunshine as that which is now the source of all terrestrial life."

The Modern Lengthening of the Anticipated Life of the Sun

From a consideration of the same figures, Lord Kelvin was certain that "the inhabitants of the earth cannot continue to enjoy the light and heat essential to their life for many million years longer, unless sources now unknown to us are prepared in the great storehouses of creation." To those accustomed to investigate the tardy processes of Nature, even 17,000,000 years seemed a very small span of life, and for years scientific men were obliged to regard the earth as an already moribund planet. Yet there were still things to discover. So long as men knew of no better fuel than coal, and could stoke the sun with nothing better than falling stars, they could not possibly give a much longer life to the sun than Helmholtz and Lord Kelvin allowed it, but with the discovery of radium and radio-active substances the sun at once acquired much longer expectation of life.

In the sun there are large quantities of the gas helium, and helium, as we know, is a product of the decomposition of radium; therefore the sun probably contains radium. Indeed, it were strange if the sun contained no radium, when radium is contained in the sun's daughter, the earth. But we do not require to be content with probabilities, for the spectroscope actually detects uranium

in the sun. Certainly there are uranium and radium and other radio-active substances in the sun, and, since 2·5 parts by weight of radio-active matter in a million would keep the sun going, we may allow the sun many million more of years to live.

When the Earth Freezes in the Darkness of a Perpetual Night

We must not, however, suppose that radio-activity can give eternal life and heat to the sun. Even if the sun contain radio-active substances it must in time burn out, and when the sun is burnt out the earth, so far as we can see, will enter upon a paralytic and frozen existence. After a certain definite period the sun will gradually give less and less light, and less and less heat, and earth will be left to freeze in the darkness of perpetual night.

A picture is often drawn showing another ending to the world, or at least to the organic life upon the planet. It is assumed that the earth will have an end like the end of the moon. We know that the moon is now an ashen desolation, without air, without water, without any kind of living plant or living being. We know that it now rotates only once in a lunar month, so that one side of it is ever towards the earth, and the other side "unguessed by mortals," and so it has been supposed that in time the earth will rotate only once in a year, and turn one hemisphere continually to the sun, and the other hemisphere continually away from it.

At present the earth revolves once on its axis in a little less than twenty-four hours, but the tides are signs and symptoms of a friction that gradually retards its rotation. So slight is the retardation that in a thousand years it may not amount to more than a thousandth of a second.

Some Gloomy Guesses at the Fate to which the Earth is Going

Still, in time, the earth will inevitably slow down, till its year comes to consist of one day, and till it presents only one half, and always the same half, to the sun. Then, in the words of an American professor of physiography, "One half of the world will have perpetual night, and the other half perpetual day—the day half exposed to the blazing heat of the sun, the night half to the cold of the Arctic regions. . . . All the water on the sunward side will be driven into space, and that on the dark side will congeal into oceanic glaciers. Then, when both air and water are gone, the temperature of the sunward side will approximate to that of boiling lead, while the dark side will drop to the bottom of the temperature scale, about 490 degrees below the Fahrenheit zero."

That is a dark and gloomy picture, but it is rather too definite and dogmatic. Granted that the earth will some day come to a standstill, and present one side to the sun, it does not follow that the other side will be so hopelessly frozen. Under such circumstances the side next the sun would probably melt and "all the seas gang dry," but there would be a certain zone between the hot and the cold where life might be possible, so far at least as temperature is concerned; and no doubt if life were possible and if man were alive he would be able to utilise the heat of the hot side for the benefit of the cold side. But, apart from all this, probably long before the earth ceased to rotate on its axis the sun would be burnt out, and the dead earth would gaze upon a black, burnt-out sun. The fate we have to look forward to a thousand million years ahead is a dead earth spinning before a dead sun, not a living earth roasted by a blazing sun.

But May not Men Learn How to Make Heat and Light for the Earth?

If we look far enough forward we see a steady reduction in the amount of heat and light given to the earth by the sun, but not for a thousand million years or so will the reduction begin to be a serious matter for the world; and in a thousand million years or so man may have the whole cosmos at his service, and may be able to utilise distant living suns in place of his near dead or dying one; or he may be able to make light and heat waves without the mediation of a sun at all. What power evolution of the brain may give man in the course of a thousand million years, who can say? When one looks back at the amazing progress of man in the last few hundred years nothing seems impossible to him in the years to come. Who knows but that in time Man may be able to avail himself of the wealth of solar radiation that at present seems squandered in empty space? As Sir Robert Ball points out, the daily heat and light of the sun would suffice to warm and illuminate two thousand million planets as big as the earth; and out of every ten million pounds' worth of heat issuing from the sun the earth gets only one pennyworth. Perhaps some day we shall retrieve some of this waste, and even store it against a rainy day.

Certain it is that any reduction of the sun's heat and light will take place, if it

indeed do take place, gradually; and certain it is that, whatever happens in a thousand million of years, man will be ready to make a tremendous fight for his life. If he be robbed of air, he will manufacture air; if he be robbed of water, he will manufacture water; if he be robbed of heat and light, he will make heat and light. The will to live is strong, and man will not die. We have heard of late years of the canals in Mars, and how the Martians are probably making a last fight for life along the banks of the canals which conduct water from their Poles. And if the worse come to the worst, man will fight for his life as the Martians are supposed by some to be fighting for their lives.

But thoughts of a thousand million years ahead are long, long thoughts; and, after all, the earth is part not only of the solar system but of the cosmos, and we know little yet of earth's cosmical relations.

Other Contingencies, which Science Suggests, May Shorten the Earth's Career

Our system seems to form an independent, isolated unit in space, but it is really rushing at a tremendons pace towards the constellation of Hercules, and what adventures, good and bad, it may meet on its journey, who can tell? All space is thronged with dark, dead stars, which as far outnumber the bright stars as ordinary flies outnumber fireflies; and as the earth careers through space in the retinue of the sun, a collision with a dead, dark star is not so very unlikely. In such a case the heat generated by the collision would suffice to reduce both the dark star and the earth to a state of incandescent vapour. If there were no actual collision, and both bodies merely passed within each other's gravitational influence, there might be sufficient stress to reduce the whole earth to dust. Or perhaps the earth might be captured by another passing sun. Such are the dangers of travelling in the realms of lonely and unchartered space.

Even without death, or complete paralysis of the physiographic and geologic energies of the earth, the earth might, in various ways, become no longer habitable. In its course towards the frozen terminus that we have suggested, many things may happen to it that, without destroying it utterly, may destroy much or all of the living population it carries. We have seen, for instance, that within geologic times the temperate zones of the earth have been overwhelmed with enormous glaciers, and there is no reason why glacial periods far more formidable than those of former days may not devastate the face of our planet. As we have seen, we do not really know the cause of the glacial periods, but, whatever the cause may have been, it may quite possibly operate again, and operate even more effectively.

More Magnificently Doleful Forecasts of What May Be

Nikola Tesla thinks that not ice but fire is likely to destroy the life of the globe. He believes that, "as the atmosphere is so fully charged with electricity, the result will be a gigantic explosion by spontaneous combustion, when the world will be entirely circled with flame, which in the space of a few seconds will destroy all life." Grant Allen, again, thought that one day the crust of the earth would break up like ice in a thaw, and make an end of all life. More likely than any of these accidents is some fatal alteration in the atmosphere. It is quite probable, as we have seen, that the composition of the atmosphere has altered a good deal in the course of the ages, and that there is a much smaller proportion of carbon dioxide in the air now than in the Carboniferous era; and it is quite possible that an era of tremendous volcanic activity might add sufficient carbon dioxide to the air to choke all living creatures, or that all the carbon dioxide might be gradually abstracted from the air, with equally fatal consequences. Again, part of our atmosphere might be stolen by some large, passing, planetary body, or a comet's tail might add some poisonous gases to it. What dangerous gases, indeed, there may be in the upper layers of the atmosphere we do not know, and these by diffusion might some day reach the lower strata.

Why Should Not Life be Quickened into Higher Manifestations in the Future?

We have said that the extinction of the sun is not likely to occur for a thousand million years or more, but the nature of solar radiation may change very greatly as the sun cools, and as its heavy atmospheric vapours condense; and an alteration in the nature of solar radiation might have momentous consequences for the life of the globe. At present the solar radiations—the actinic rays and light-rays and heat-rays—as filtered by the solar and terrestrial atmospheres, are favourable to life on the earth, and probably play a very subtle part in all vital phenomena, but a comparatively small alteration in the composition of the solar radiations we receive might

destroy life altogether. On the other hand, it must be noted, it might produce much higher manifestations of life, both in the animal and the vegetable world, and might hasten evolutionary progress in many ways. We do not know yet how much we owe to the sun, and are rather inclined to regard our great luminary as merely a lamp or a fire, but it is far more than that. It has many radiations, and all its radiations are of importance to the world. Nor have we a right even to assume that the sun is cooling down. For aught we know, its temperature may be still increasing, and in that case it may become, instead of the King of Life, the King of Death, and may quickly destroy what it has created.

Of anything like a universal deluge there is not much fear, but it is always possible that some great alteration of the land level may lay bare large tracts of lands at present under the sea, or may submerge large tracts of the present continents.

Has Not the Great Law of Progress Greater Things in Store?

We have seen that a drop of 600 feet in the level of the land would lay bare 10,000,000 square miles of land that are at present under the ocean, and that a rise in sea-level of 2000 feet would submerge the greater part of the dry land. Unless, indeed, an accession of solar heat should rapidly evaporate the ocean, there seems no likelihood of any rise or fall to these extents; but, still, rises and falls, gradual or sudden, are certain to occur and to alter the physiography of the earth.

What changes evolution may produce in the course of ages in the fauna and flora of our planet we cannot here discuss, but the same evolutionary processes that produced man from an amœba, a lily from a bacterium, have surely still greater things in store. Such, briefly, are most of the future possibilities of the earth, but one contingency still remains to be mentioned.

We have said that the heat of the sun is chiefly due to its radio-activity, and may be increasing. But the same may be said in the case of the earth; it is quite possible that the heat of its core may be increasing. A very small quantity of uranium in the central parts of the earth would, in the course of a hundred million years or so, give rise to a temperature of about 2000 deg. Centigrade. Professor Joly says, "The conclusion that the earth's interior temperature is rising seems the logical outcome of the probable conditions, taken along with Kelvin's proof that the central parts of the earth are thermally isolated for immeasurable periods of time from the surface. . . . . The quiet accumulation of radioactive energy proceeding throughout the mass will, near the surface, make good the radiation loss, but in the interior, where no means of escape exists, must collect during the passing geological periods. There can be only one result—general surface vulcanicity and reversion to temperature conditions which may involve the repetition of the entire sequence of events."

The Hand that Lighted Life's Torch can Light it Again

And if such a conflagration may occur, it may have occurred many times before, and may occur many times again, and we are brought face to face with the conception of worlds that are born and die, and are born again to die again. On this conception the earth carries in its own core the fire that is to destroy it and the fire that is to remake it.

Throughout this attempt to gaze forward into the future of the world we have been obliged to suggest possibilities rather than to narrate certainties. The energies of the world, the energies outside the world that act upon it, are so complicated in their mutual relationships that we cannot fully understand their working, and can merely guess the future from our limited knowledge of the past. We do not know what is to come, but it does not require great faith to believe with Tennyson that there is "one far-off, divine event to which the whole creation moves."

The Great Progressive Story of the Earth Not Yet Half Told

We can foresee many possible dangers, we can foresee many inevitable changes, but the Power that brought men and birds, and roses and rivers, out of a fire-mist will lead the earth past all dangers, and will make all changes changes for the better. A million million dangers had to be faced in the upward evolution of man—mammoths and glaciers and microbes and earthquakes—and yet man now walks erect beneath the stars, and the Power that led Man on his upward path will surely guard the planet which is Man's home. We have every reason to believe that in the æons to come Man will evolve into a yet higher organism, and the world will become more and more suited for his habitation.

TIME'S VOYAGE WITH LIFE'S TRIO—HOPE, PLEASURE, AND MEMORY—PAST, PRESENT, AND FUTURE

A SYMBOLICAL SCULPTURE BY STECCHI, ENTITLED "LA TRAVERSEE DE LA VIE"

LIFE'S ULTIMATE DESTINY

What Will Happen to Life Should the Earth and the Universe Run Down ?

THE DISCOVERY OF INHERENT ENERGIES

The greater part of our long study of life has been concerned with its history, from which we have been enabled to infer something of its nature and mode of action. We have now to sum up the situation as it exists for life upon our planet, and to say what we can as to its probable destiny. Our inquiry must of necessity be confined to life where alone we certainly know it, as a denizen of the astronomical body called the earth. But we shall be careful not to deny that the phenomena of life, which we have come to regard as essentially phenomena of mind, may be exhibited on other worlds than ours.

It may be, indeed, that in the natural history of the various worlds which inhabit space there is a period during which life appears, and that this period has yet to be in the case of such a planet as Jupiter, while it is already past in the case of such a small and rapidly cooled body as the moon. There has long been a tendency on the part of many students, since the discovery of evolution in the middle of the nineteenth century, to assume that life is solely a terrestrial phenomenon, which could not occur elsewhere than under the conditions of our earth. That is surely altogether too material and local a view of life, and one which is utterly incompatible with the conception of life as a manifestation of mind. Wherever not-mind is, as matter and energy, there mind must potentially be, and may find ways of expressing itself. Granting that, and no longer presuming to assume that the highest thing in the Universe is confined to one tiny satellite of one of the least considerable of hundreds of millions of suns, we may proceed with the special inquiry which concerns us so intimately, and which alone we can hope to conduct with any success. What are the future prospects of terrestrial life ?

Destruction of the fruits of all the ages of vital progress was Darwin's "pet horror." His great advocate and champion, Huxley, dealt with the subject in more detail.

"If our hemisphere were to cool again, the survival of the fittest might bring about, in the vegetable kingdom, a population of more and more stunted and humbler organisms, until the 'fittest' that survived might be nothing but lichens, diatoms, and such microscopic organisms as those which give red snow its colour; while, if it became hotter, the pleasant valleys of the Thames and Isis might be uninhabitable by any animated beings save those that flourish in a tropical jungle. They, as the fittest, the best adapted to the changed conditions, would survive."

Of these two possibilities, destruction by cold is what we apparently have to anticipate. Yet destruction by heat is not inconceivable.

A few years ago Mr. Ellard Gore published a paper, "A Possible Celestial Catastrophe," in which this subject was further considered. There is a Biblical verse, "The heavens being on fire, shall be dissolved, and the elements shall melt with fervent heat ; the earth also and the works that are therein shall be burned up." Astronomy is able to show that such results might, indeed, follow from natural causes under certain conditions. For instance, the temperature of the crust of the earth might be greatly raised by an outburst of heat from its central core. In such a case terrestrial life, as we know it, would disappear, and man would be no exception to the rule. Some geologists of today suppose that there is something, after all, to be said for the "catastrophic" geology which Lyell, in his "Principles of Geology," overthrew ; for there are physical facts which suggest that the hot centre of the globe may

indeed have asserted itself in this way from time to time. But contemporary opinion is still against this view.

Then there is the possibility, by no means unreasonable, of outbursts in the sun. As Mr. Gore says, "Were the sun to suddenly blaze out, like the 'temporary' stars recorded in the annals of astronomy, then the earth would certainly be burnt up, and at least everything on its surface would be reduced to ashes." But there is another remarkable possibility.

How Long Should We Have Notice Beforehand of a Stellar Collision?

No bright star is to be feared as an enemy of the sun, and therefore of the earth. Even if the nearest known star were travelling towards the sun at ten miles a second, it could not reach us for scores of thousands of years. But dark stars, which astronomers cannot detect, have to be reckoned with; and it is quite possible that, in the course of the sun's journey through space, such a star might be encountered.

Should such a collision occur, there would be a rapid end of terrestrial life. We need not fear, however, that anything of the sort may be now imminent, for astronomers would be made aware of what was to happen long before the actual catastrophe occurred. When the approaching dark body came within a certain distance of the sun, it would shine by reflected light, as the planets do. It would first become visible far beyond the solar system. For a long period its motion would be very slow, owing to its great distance from the sun. It would probably be first seen as a faint star of, perhaps, the ninth magnitude.

Mr. Gore has made some calculations as to the movement of such a body, on certain reasonable assumptions—as that it had the same mass as the sun. In such a case we should have long notice of the ultimate event. But a smaller body, even only the size of the earth, would give us less notice, though its advent would be no less disastrous.

Will Life Perish Finally from the Earth bv Thirst?

According to Mr. Gore, "Such a body may possibly be now approaching us. If only the size of the earth it might easily escape detection until well within the orbit of Uranus, and we might then have only a few months' warning before the final catastrophe occurred." But the long records of the past immunity of the sun and earth from such events suggest that we need have little fear. Probably unattached and irresponsible celestial bodies, liable to "run amuck" in the fashion suggested, are very few or non-existent. Else the solar system could scarcely have been travelling through space at twelve miles a second for hundreds of millions of years without mishap.

Indeed, it is not heat but cold that we—or, rather, our remote successors—have to fear. To this Professor Percival Lowell would add thirst, on the hypothesis that the earth is gradually losing its water, as he believes is happening on Mars, and as seems to have happened in the case of the moon. We know no form of life that can exist without water, which is essential for the chemical phenomena by means of which life shows itself. But this loss of the earth's water is a doubtful question, which need not here concern us further. It is well to remember that the earth is much larger than either Mars or the moon, and therefore has much greater gravitational control over the water and other gases in its atmosphere. But, as regards the advent of cold, the case is much more definite.

The Faultiness of the Theory of Final Poison by Noxious Gases

In our study of the planetary facts of life nothing has become more evident than their cyclical character. All sorts of definite processes, which tend towards a limit in some direction, are compensated by other processes in the opposite direction. There used to be a theory that the amount of carbonic acid gas in the atmosphere must accumulate until the last man, or chamois, expired of suffocation, on the top of the highest available mountain, drowned at last in the rising sea of irrespirable gas. But speculators forget that the green plant everywhere decomposes the carbonic acid produced in such large quantities by the respiration of animals, and restores the oxygen to the atmosphere, retaining the carbon which animals will consume at a later date, and will burn over again. This is the great carbon cycle, an essential part of the balance of living Nature; and, so far as it is concerned, the earth might bear abundant life for ever.

Similarly, we discover that the death of innumerable hosts of living individuals, every day, does not mean the locking-up of valuable chemical elements and compounds which life requires; for other forms of life, called the microbes of putrefaction, attack these corpses, and unlock their invaluable contents, which then become available for further developments

of life. Thus, every atom in the body of any one of us, or of any creature now alive, must have been part of the body of myriads of other living creatures in the past, and their death has not been allowed to arrest the fruitfulness of life.

And yet, notwithstanding these and many other instances of the extraordinary economy with which life manages its affairs, the fact remains that life does require an income to spend, and cannot do without it. That income is the light and heat of the sun—or rather, that minute proportion of the light and heat of the sun which strikes our earth and pierces our atmosphere. It is of no avail to point out how astonishingly well this income is managed. It is handed on, in many forms, from one living creature to another, especially from the green plants as a whole to the animal kingdom, and it serves the purposes of all in turn. But it is ultimately spent, in the long run. Every moment as we now read or write, *heat* is leaving our bodies and passing into surrounding objects. That heat was originally solar energy. It travelled from the sun, reached certain green plants, was turned by them into starch and sugar, which we consumed, and then burnt up in our bodies, producing the heat which is now leaving them. That heat is lost to life.

The Dependence of All Life on the Earth Upon the Sun

It is not lost to the Universe; it is not annihilated, but it cannot be *used* again, any more than the wheel can be turned by the water which has passed. The process which our own bodies are illustrating at this and every moment is none other than a minute part of the general loss of availability which Lord Kelvin called the "dissipation of energy," a process which persists, no matter how wisely or efficiently the energy is employed meanwhile. It is dissipated or degraded, tending to assume the unemployable form of a dead level of heat. Living creatures make amazing use of the energy which passes through them, but it undergoes dissipation through them, nevertheless, as everywhere else. In this great respect there is no cycle of life, no balance of living Nature.

On the contrary, life is a beneficiary of the sun. So long as we living creatures receive a sufficient income, or indeed any income, of energy from the sun, we will use it to the best of our ability, and make it serve the life of a long succession of living forms, green plants, men and microbes, in turn, but even we cannot spend our cake and have it. Some waste, in the form of the dissipation of energy, which goes on everywhere else, must occur with the energy which passes through our bodies; so that, if life is to persist, the solar allowance for it to live upon must be maintained. Marvellous though life be it cannot create physical energy. There is no such thing as "vital force" in the sense of energy *made* by life, and added to the energy of the physical universe. Something of the sort used to be thought, but experiment has proved the contrary.

How Long Will the Sun Supply the Wherewithal for Life's Energy?

Every iota of energy displayed and expended by every living creature has had to come from somewhere. Life did not make it, and cannot do without it, marvellously though life may transform, use, and direct it. All these latter processes are within its competence, but to create energy and to do without energy are not. To this rule man is no more an exception than the humblest form of life that can be named.

The duration of life's solar income is therefore a matter of the first and last importance. So long as that income is maintained, life will use it. We need not fear that life will grow old, or lose its powers. It is new every morning, like the rest of the Universe, and will be gaily inventing and projecting and achieving a thousand millions of years hence as today, if only it has the wherewithal. But the astronomers and physicists are upon nothing else so definite and so consentaneous as upon the impossibility of the sun's eternally maintaining the output of energy by which terrestrial life lives. They point out that the sun is no more capable of creating energy than life is, and that its tremendous output cannot be compensated by any influx from without.

The Continuous Loss by the Sun of its Store of Energy

The available sources of such influx are the light and heat received upon the sun's surface from other stars, and the impact of meteorites and other such small bodies which the sun may sweep up on its journey through space. The total solar income from such sources is practically negligible; and the necessary conclusion is that the sun is losing its store of energy.

It may or may not be actually falling in temperature—that is a question in cosmical physics of great difficulty—but the store of energy must be diminishing, and must some day be depleted. If the sun were

made of coal and were burning, it would have burnt itself out long ago. If it obtains its energy from its own gravitational shrinkage, that process is obviously finite. Even if there is present a proportion of radium in the sun, as astronomers have inferred from the known presence of helium, a radium product, yet, even so, the sun cannot produce energy for ever. Furthermore, space is full of dead suns, dark and cold bodies which were doubtless once bright and hot; and they evidently indicate the state of things to which the brightest suns must come.

What, then, of the prospects of terrestrial life? Whether or not the sun be now actually falling in temperature, that fall must some day occur. The sun will slowly begin to grow cold. Less heat and light will reach the earth. The Polar ice-caps will increase in extent, and life other than that of the humblest sea-water forms will be made less possible than ever at the extremities of our globe. The flora and fauna of the earth will be necessarily modified in form and distribution, as the climates of the various zones slowly alter.

The Shrinkage of Terrestrial Life in Proportion to the Loss of Solar Heat

Alpine forms of life, we should suppose, will be left to keep the flag flying in what are now the temperate zones. The animals and plants which now exist in colder latitudes, or corresponding types of the future, will replace the forms which are adapted to greater warmth. The climatic conditions to which we are accustomed will be maintained longest in the torrid zone, where the rays of the waning sun fall most directly on the surface of the earth, through the shortest distance of atmosphere, and thus retain most of the power with which they were endowed when they reached the outer limits of our globe's gaseous envelope.

We can imagine that the struggle for existence, not least within our own species, would become intensified under such conditions. The animal and human population of the globe would be very seriously diminished in numbers, for the sufficient reason that the supply of nourishment would be restricted. The green plant is what would suffer first when the supply of solar energy failed; and the serious limitations of the area on which food could be grown would determine the numbers of the animal kingdom. There can never be many more mouths than there is food to feed. We must not suppose that mere improvement of devices for protection against the cold would be of any substantial use. No doubt cosy homes of sorts could be made beneath the surface of the ground, where any temperature desired might be obtainable, perhaps long after the sun's heat had begun sensibly to fail. But mere protection against cold is of no use if there is nothing to eat; and for food we require the co-operation of the green plant. Our successors might learn to do without that co-operation, as has been suggested elsewhere in this work, but they would still be dependent upon the solar energy, even though they had contrived some other transformer than the green leaf, and that energy would be failing. Therefore, the numbers of animals (if room could be found for any), and of men, would be seriously diminished in proportion to the diminution of life's solar income.

The Failure of All Life with the Failure of Daylight

Last scene of all, or last but one, in this eventful history would presumably be the disappearance of all warm-blooded forms of life—man, birds, and mammals in general. All forms of animal life, or nearly all, would have to follow. The green plant, living in its elegant and inimitable way upon the light of day, would have to vanish when day became grey and dark; until at length, as Huxley suggested, "the 'fittest' that survived might be nothing but lichens, diatoms, and such microscopic organisms as those which give red snow its colour." When light fails, all the higher forms of life must fail. Light is not merely to see by. It made the eye it illuminates. The higher animals and men could not grope about in darkness, and make the best of it, because they would have no food to live upon, failing the light-energy which the green plant converts into our nourishment. Failing the green plant, and the bread which is its typical product, the staff of our life would be removed, and we should fall.

The Humbler Forms of Life that will be Left to the Last

The history of terrestrial life would thus present a long, slow rise and a long, slow decline. The latter stages would be represented by humble forms of life not so dissimilar from those in which life began. It is probable that life began in darkness upon our planet, at a time when the rays of the sun could not pierce the dense atmosphere of those hot times. And on our present supposition life would show its declining stages in darkness also, though in darkness of a very different kind, due not to any dense screen of opaque gas, but to the

feebleness of the sun's rays, now obstructed by an atmosphere of increasing rarity. We may suppose that life would hold out as long as water remained liquid. The astonishing resistance of living organisms to cold has been completely demonstrated of late, and contrasts notably with their comparative susceptibility to heat. Bacteria will survive six weeks' exposure to the temperature of liquid air. Arctic explorers have found living organisms in sea-water in all latitudes. Assuming, then, that water remained at all upon our planet at this epoch, we must suppose that life of humble sorts would persist—at any rate, as long as that water remained liquid.

Last Stage of All, that Ends this Strange, Eventful Story

Finally, no liquid water remaining, and what water was left to the earth being all frozen, the last forms of life would have to come to an end. This cold graveyard of an earth could expect to burgeon never more until some celestial collision provided new sources of heat and light—in the course of which event, probably, the earth itself would be transformed and its identity lost.

Such, in all moderation and sobriety of statement, is undoubtedly the terrestrial prospect. We may not nowadays accept the view of Lord Kelvin, that the loss of available energy is a universal process, and that there can be no resurrection. Elsewhere in this work the modern arguments against that view, which was always opposed by Herbert Spencer, have been detailed. But those arguments do not at all affect our belief that the sun must cool. On the contrary, the newer atronomical evidence as to the evolution of stars, beginning with the celebrated work of Sir Norman Lockyer, strongly confirms our belief as to the cold future of the sun. Nor is there any question as to the dependence of earthly life upon the sun. There may well have been an earth-sustained period of earthly life, when the surface of the planet was so hot that the sun's rays were not needed for the maintenance of life. That stage has passed, and our dependence upon the sun is absolute.

Can Mind Do Anything to Avert Life's Overthrow?

New discoveries in physics may greatly prolong our estimates as to the sun's powers of future radiation. The presence of radium in the sun may vastly extend the duration of its powers, but that cannot be more than merely putting off the evil day.

Is there, then, no imaginable escape for terrestrial life, including the human species, from the tragic and chilly fate which Darwin describes in a letter to Sir Joseph Hooker, with the comment, "*Sic transit gloria mundi*, with a vengeance"? Our answer to this question will depend upon our theory as to the nature and powers of mind. On the view which many men of science entertained in the nineteenth century, the possibility of any rescue by the mind does not arise. For we may remember that upon the materialistic or mechanistic view, the mental phenomena displayed by living creatures, of course including those displayed by man, are mere "epi-phenomena," as Huxley called them, by-products and consequences of the chemistry of the organism, *and impotent to effect any changes in anything*. We think we do things, but we err; they are done to us, and we notice them. On this theory, life must go through with its sentence, and no help can be expected from that showy but impotent by-product of life which we call mind.

But in the twentieth century, under the guidance of such men as Bergson, Driesch, and McDougall, we think rather differently of mind, and are disposed to credit it with rather more powers than the materialists supposed. Let us for the moment leave over the philosophical considerations, and ask what mind might do—if, indeed, mind can do anything.

The Energy that is Everywhere, Waiting for Mind to Find It

It could not create energy available for life's purposes when the sun's energy failed. It could not construct those machines we call the bodies of living creatures in such a way that they would work without energy. Not for a moment can we credit mind with the power to abrogate and defy the laws of the physical universe. If what we call the law of the conservation of energy be valid, if the truth that you cannot spend what you have not got to spend remains true, then life in time to come will require *a source of available energy* for working its machines, no less than today or in the past. A muscle, as Professor Macdonald, of Sheffield, has lately shown, may be the most economical machine in the world, turning into mechanical work no less than 25 per cent. of the power supplied to it; but power must be supplied to it, nevertheless. The light of the glow-worm may be as superior in efficiency to any lamp made by man, as a muscle is to any of his machines, but it requires energy for its consumption, none the less. If the sun is to fail us, where on earth is the energy which life might use to

live by, supposing that mind could somehow learn how to use that energy in the place of sunlight?

Everywhere, is the answer. Within every atom exists a fund of energy so large, as compared with all the energy hitherto known, that this becomes a mere nothing. The Hon. R. J. Strutt, F.R.S., the eldest son of Lord Rayleigh, has constructed a radium clock which will go for ages without winding. This clock does not contravene the law of the conservation of energy. It is driven by the explosion of radium atoms with which it has been supplied, and the liberation, as available energy, of the energy by which those atoms had been built up and were held together. As for heat and light, essentially identical with the heat and light whereby the sun maintains the life of our planet, we know well that radium produces heat and light in extraordinary quantities for astonishing periods, without any energy being supplied to it. They are the transformed energy which was within the radium atoms. If we had enough radium, and could get it together, or set up small "suns" of it here and there, we could live by it, and vegetables could grow by it, just as they can be grown by electric light. Only, we have every reason to suppose that there is but very little radium in the crust of the earth.

Will Man Ever Find a Clue for Using Gravitation?

Our answer, however, to the question where on earth the supply of energy is to be found was "everywhere." And it is so. Radium atoms only illustrate what is the fact of all atoms. The atoms of this ink and paper, of the air about us, of everything we touch or see, are crammed with energy. Probably they all yield this energy in the course of time, though none do so as rapidly as radium does. If we could tap the energy of the atom, we should not need to trouble ourselves about the stored-up solar energy o' coal under our feet, or even the gradual failure of the sun's powers. That is to say, the intra-atomic energy is so [redacted] amount, there are so many [redacted]ad, and their store is so rich, [redacted]uld avail for countless ages. [redacted]nother section will be well aware that, even so, the store of energy available would not be infinite. No more than the living organism, or than the sun, does the atom *create* energy. But, given access to the intra-atomic energy, man's dependence upon the sun would cease, provided that he could invent the necessary machinery for turning the energy from this new source into the forms he wants—as to which proviso there need be no doubt.

Another possibility, of strange speculative interest, has been hinted at by M. Maeterlinck. The time may very well come when man's mind obtains the clue to the action of gravity, and thereafter the power to control it. Should such a time come, man might be able to steer his planet where he pleased, being no longer subject to the continuous action of the uncontrollable force which binds us in our orbit round the sun.

Whatever be the chances involved in such a suggestion, they depend upon the conception of life consistently maintained throughout this section, and which comes to be of crowning importance at the last.

The Influence of Intelligence on the Evolutionary Process

For M. Maeterlinck, for those who are now studying the atom, with the hope of being able to tap its stores of power, and for the ordinary man living his ordinary life, living creatures are not merely puppets, to which things happen. They can do things, by virtue of the desire, the purpose, the will to live, which animates them. They are limited, conditioned, baulked by the laws of matter, by the "cussedness" of external things, and by their own bodies, for too often, though the spirit is willing, the flesh is weak. Nevertheless, the directive power of the spirit remains. For the vitalist, this is the central fact of life, which he sees to be Mind essentially; or, as Bergson puts it, "of the psychological order."

Several years ago, before Bergson had served us all by his great book, the present writer made what small protest he could, by way of a demurrer, against the purely mechanical view of the future of life upon our planet. Neither in Herbert Spencer's "First Principles," nor in the physicists' theory of entropy, it was argued, was sufficient allowance made for "the influence of intelligence upon the evolutionary process;" and that "we will do well, in predicting the future of matter and motion, not to deem impotent the factor of mind."

The Variation in the Fate of the Thinker Compared with that of Physical Nature

But this protest means more today than was then realised, for Bergson has taught us to recognise mind in all life, and not merely in the life of man. We are therefore simply forbidden to infer the future of life from what we consider we know of the laws of matter and motion. If those laws make life as a by-product, then to investigate

physical processes and to define their cosmic trend will indeed be to define the destiny of life. Let the students of cosmical physics say what is happening, and we can define the fate of living things. But if life is mind, and is not an "epi-phenomenon," or by-product of the changes in matter and energy, these predictions will be insecure. If we attempt to make such predictions about any individual creature, it defeats us. According to the laws of matter and motion, it should come to such and such consequences, but nothing of the sort happens, for the living creature, while we are calculating, makes up its mind (which we had not noticed) to do what it wants, and avoids the imminent fate which would have overtaken any not-living collection of matter and energy in similar circumstances. Now, if the physicists cannot accurately predict the fate of any living individual, because of the existence of a directive factor which they cannot measure, certainly they cannot predict the fate of life at large. In the last chapter we saw that man, as the most intelligent form of life, is already taking over the control of all the life of his planet. He exterminates, he breeds new types, he establishes new environmental conditions to which old types have to adapt themselves, he maintains "Nature reserves" where the old forms may persist unmodified.

The Rashness of the Scientific Conclusions About Finality

We cannot admit that the cooling of the sun must necessarily put a term to this process. We see that there are sources of energy nearer at hand, not infinite, yet almost illimitable, which man may very soon learn how to employ. Many physicists and astronomers are even uncertain how far the doctrine of the dissipation of energy is sound; and it may be that, just as, according to the law of the conservation of energy, no energy is ever destroyed, so no energy is ever finally reduced to the somewhat mystical state described by the physicists, in which, though intact as energy, it is inert.

It is not the truly scientific but the unscientific man, said Darwin somewhere, who sets limits to the possibilities of knowledge; and the history of man's achievements declares the truth of Darwin's words. The things asserted impossible to be done or to be known have over and over again been done and known. Perhaps the mind which is in all life, and above all in man, is part of the Mind Universal, which may be the Prime Mover of all things. Perhaps Dante was symbolically expressing a deeper truth than mind-denying "science" can see when he declared that Love moves the sun and all the stars. These things are too high for man's searching and thought to decide. Let us beware of finality, or of too great a confidence in the tentative conclusions of science.

Science is very young and small, and Truth is very old and great. Many of the most confident conclusions of the nineteenth century, not least in biology, have survived only to point a moral in the 'teens of the twentieth. We see now that we know nothing whatever as to the origin of life, and that, unless we assume rudimentary life to be omnipresent, we can never postulate a beginning for life as we know it.

The Mistake of Regarding Living Creatures as Automata

We see now that the origin of species by natural selection was a theory of the destruction of species by natural rejection, and that the origin of new forms is as mysterious as the origin of the old ones from which they spring. We see now that the expedient of regarding all living creatures as automata is inefficient, because they persist in behaving as beings that have will and purpose; so that, the more we insist upon regarding them as machines, the more certainly we miss the very facts which make them alive, and on account of which we study them.

Such are the chief gains of the twentieth century in the science of life, and we see that they are all negative; they amount to no more than a rejection of false or partial views which were taken for the whole truth a few decades ago. The origin of life, of species, of mind, is yet to seek; the problem of explaining the occurrence of mind in living things, unless we recognise it to have been there in the first place, is seen to be an insoluble one. The attempt to solve it has led the acutest thinkers into the most grotesquely false assertions.

The Presumption of Setting Limits to the Powers of Life

It is time to make a fresh start, trying to concentrate upon the essential facts of living things, which are the facts of behaviour. The more we do so, the more we see that all living things behave, that a purpose, a will, an *élan*, a power of self-direction and self-expression, is their common character, and that to attempt to set limits to its powers would be presumption, when we remember their past achievements, and our incapacity to measure the Infinite and Eternal from which they proceed.

ROCKS ON THE ENGLISH COAST COVERED WITH BLADDER AND OTHER WRACKS

The photographs on these pages are by J. Holmes, J. J. Ward, Hinkins & Son, J. Crabtree, S. C. Johnson, and others.

THE PLANTS OF THE SEA

Their Colouring and Susceptibility to Depth, to Temperature, and to Saltness

WHY ARE THE SAME PLANTS AT EACH POLE?

THE study of life is always interesting, no matter what phase of it be chosen, but there is no more fascinating field than that of marine biology. There is always something mysterious about the living things in the sea—a feeling that no matter how much we may find out, there is more, much more, that remains undiscovered. Lands and continents may be explored and surveyed until not a square yard remains unknown, but no man can probe to the uttermost the depths of the ocean, nor examine more than a fraction of its contents. We know much of the monsters of the animal world that in olden times ranged its waters, and the largest forms of animal life still disport themselves there; but scientific knowledge of the plants of the sea is infinitely less advanced, and indeed has only in recent years made much progress.

Considering how universally distributed are the sea plants, or sea-*weeds*, as we curiously term them, it is rather remarkable that ancient literature should have such sparse references to them; but, as a matter of fact, one finds only the most superficial mention of them. The Bible refers to them but once, in the words of Jonah, "The depths closed me round about, the weeds were wrapped about my head." Latin and Greek authors passed them over with similar contempt or ignorance. The earliest writers on biology frequently described many sea animals as plants, which is not surprising when we consider how unlike animals many of them undoubtedly are at first sight.

The prevailing colour of land plants is the universal green, only relieved by the brilliance of the varied parts of the flower and the colour of the bark of trees, but there is no such uniformity in the colouring of sea-weeds. Indeed, it is their wonderful colouring that would first attract the attention of the observer looking at a forest of sea-weed in clear water. Nothing more beautiful in colouring can be imagined. No wonder that the colours were taken as a basis of classification, a basis which still remains in the names given to the different groups. Thus we have the *Rhodophyceæ*, or red sea-weeds; the *Phæophyceæ*, or olive-brown sea-weeds; the *Chlorophyceæ*, or green sea-weeds; and the *Cyanophyceæ*, or blue-green sea-weeds. Nor is this such an unscientific method of classification as might be imagined, for it very nearly agrees with a classification that would be made were structure and mode of growth taken as the basis in the place of colour.

When we look into this matter of colouring in sea plants, we find that it does not differ so fundamentally from that which obtains in land plants as would appear. In their ultimate colour-composition the sea plants are all really green, just as are ordinary plants, and in virtue of the same pigment, chlorophyll. Where they differ is in having some other pigments in addition, the presence of which more or less obscures the green chlorophyll. Of these pigments there are four, termed respectively phycoerythrine, or the red pigment; phycophæine, or the brown pigment; phycoxanthine, or the yellowish-brown pigment; and phycocyanine, or the blue pigment. The discovery of these varied colouring matters explains at once the wonderful combinations and shades of colour found in the sea plants.

They all differ from chlorophyll in one important and interesting feature—namely, that they can be dissolved out of the sea plants by simply soaking them in fresh water, when the coloured plants present the ordinary green of their shore relations. Chlorophyll is insoluble in water, and hence remains in plants so treated. Some fresh-

water plants exist which are also coloured similarly, but, nevertheless, these pigments are the special features of the sea plants, and their presence is due to the environment in which the plants pass their existence.

The colours of sea plants indicate in a somewhat rough-and-ready manner the depths at which the plants grow, though there are numerous exceptions. Thus the seaweeds found near the level of the high-tide mark on the shore approximate in colouring to the land plants—that is, their prevailing colour is green. Farther down the beach or rocks, covered at high tide and laid bare at low tide, we find the plants of the prevailing olive-brown tint.

Underneath these and sheltered by them red forms are found; and these, too, may be discerned in rock-pools at the bottom. At the lowest tide-level and extending into the shallow sea we notice multitudes of brown seaweeds with red ones intermingled with them, but it is only in the greatest depths which support plant life at all that the red members are found by themselves.

There is a limit to the depth at which sea plants are enabled to thrive. They become fewer and fewer after twenty fathoms (180 feet), and it is very unusual to find them beyond a depth of fifty fathoms (300 feet).

What determines the depth at which sea plants can grow? Doubtless it is a question of the penetration of sunlight through the water, light being necessary for chlorophyll to perform its all-important functions in connection with processes of nutrition. But the sea is not in utter darkness in the daytime until we reach a depth of some seven hundred fathoms or less, and it might therefore be supposed that plants would flourish up, or rather down, to that depth. As a matter of fact, however, they do not.

There is another intervening factor besides that of the mere penetration of light. There is a qualitative change as well as a quantitative change in the light which passes down through the water, and this is the further explanation. Light is composed of various rays, as we know, and the different rays have different functions and properties. Some are more active than others in the work of assisting chlorophyll in its function, and, curiously enough, it is precisely these which are first intercepted by the sea-water. The only rays of light which reach the greater depths are the blue rays and the green rays. This would suggest that the additional pigments found in sea plants, which we have named above, have been evolved as additions to chlorophyll to make up for the qualitative change in light which takes place in these depths.

BLADDERWRACK

Possibly they assist the chlorophyll to make use of what light reaches the plant, rendering it more easily affected by light. Or perhaps they afford some kind of protective influence against the excess of the blue rays which penetrate. The second view is regarded as the more probable by Mr. George Murray in his excellent book on the "Study of Sea-weeds," to which we owe many of the facts here stated. Similar protective functions are ascribed to pigments in certain land plants, which supports this view.

It is true that minute and other plants have been obtained from great depths occasionally, but they do not live there under normal conditions. Probably they have been carried down by currents. So that we have the outstanding point that colour, which is of no value in classifying land plants, is correlated with other characters in sea plants; and we need not be surprised at that, when we remember that in the sea colour is of immense importance in connection with the performance of the nutritive function. Light, then, chiefly determines the depths at which sea plants live.

The second great factor in the life of sea plants is the temperature of the water, and

it is this factor which is responsible for the geographical distribution of sea plants. Sea temperature does not vary in anything like such great degree as does that of the air on land, neither diurnally nor seasonally. It is much more constant than we are apt to suppose, the changes we appear to feel in it, when bathing, for example, being much more due to the changes in the air we are in than to changes in the temperature of the water. Thus we often imagine the sea-water is very warm at night, tested, it may be, by dipping the hand over the side of the boat. It is the night air which has got colder, and gives us that impression. Living, therefore, in a fairly constant temperature, sea plants naturally are very susceptible to changes in that temperature. They are not accustomed to them. Hence the necessity of careful regulation of the temperature in aquaria if the plants are to flourish.

Other factors, too, play a part in the life in the sea. Notable amongst these are the degree of the saltness of the water, the kind of bottom on which the plants are growing, and the amount of tidal variation in any given spot. So sensitive are sea-weeds to temperature changes that it is difficult to transfer those from great depths to artificial surroundings, especially in summer. They should be packed in ice, and must have a cool place to grow in, where direct sunlight cannot penetrate. They resent quick changes of water and exposure to air. In order to study their growth with accuracy they must be suspended in the sea at their natural respective depths, and anchored in some convenient manner. The salinity of the water has not so great an adverse effect as has variation in salinity, as may be observed in estuaries and places where fresh water is constantly arriving in varied amount according to the rainfall.

SCARLET PLOCANIUM, ONE OF THE MOST ABUNDANT OF THE RED DIVISION OF BRITISH SEA-WEEDS.

Mr. George Murray quotes a very interesting case bearing upon this point. " A canal connects the sea with a lake that receives almost all the fresh water of Mecklenburg, and many species of sea-weeds grow in this lake at places where the salinity is almost nil ; while almost all are absent from the canal, which conveys sometimes salt water and sometimes fresh." Thus we see that it is the alterations in salinity rather than the degree of salinity which adversely affect the growth of the sea fauna.

Among the primary factors in the distribution of sea plants in space must be reckoned the great and small ocean currents, which act also as agents of seed dispersal for land plants, as we have previously noted. But in the land plants, it will be remembered, we found many curious and varied adaptations to enable them to take advantage of ocean and other water currents as agents of dispersal. In the case of the sea plants there is no need for these special adaptive arrangements. The ocean currents seem to control what may be termed the climate of the sea-water, much as high ranges of mountains affect land plants. We often find the flora on two sides of a mountain range differing widely, and in similar manner the sea flora on the two sides of a continent exhibits wide variations from the effect of currents. Thus the West Coast of Africa is washed by a cold current coming up from the south, whereas the East Coast is under the influence of a warm Mozambique current from the north, and the species of sea plants vary accordingly. The fauna of the different portions of the Gulf Stream is similarly varied, exhibiting the plants of the temperate region in the Shetland Islands and the Arctic flora of Cape Farewell, both these being on the same parallel, but the latter influenced by the cold current from the east of Greenland.

BRITISH CORALLINE ON THE SHELL OF A LIVING LIMPET

The analogy between plant distribution on land and in sea may be further illustrated by observing how the vastly increased means of communication in the modern world plays a part. This is, of course, very clear in the case of land plants, but it acts, too, for those of the sea. Iron ships carry great numbers of sea-weeds from place to place, more so than did the old wooden vessels, whose copper bottoms protected them. True, the great mass of sea-water is continuous, and there is nothing of a physical nature to offer insurmountable barriers to dispersal, but the varying temperatures of seas which communicate with each other determine the exact species that will flourish in each. Lastly, in this connection, it m be noted that the species which the vario oceans have in common are, as perha might be expected, those of the smaller ty rather than the great sea plants.

A very interesting fact is observed if t flora of the two Polar regions be compar with each other. There are no less th fifty-four species at least—perhaps mor which are common to the Arctic an Antarctic waters, but which do not oc in the intervening tropics, and these plan must have been divided from each oth by this intervening mass of warmer wat from time immemorial—indeed, ever sin the world has known the meaning of climat differences. Let us inquire how this stri ing resemblance comes about.

Sir John Murray, the reports of t "Challenger" exped tion, puts forward t following theory o the point. "In Ca boniferous times t surface temperature the sea could not w have been less th about 70 deg. Fah and the same temper ture and the sam marine fauna prevail from equator to Pol the temperature n being higher at t equator. In ear Mesozoic times cooli at the Poles and diffe entiation into zones climate appear to hav commenced, and tem perature conditio did not afterwards admit of coral reefs in t Polar area, but the colder, and hence dens water that in consequence descended to t great depths of the ocean carried with it large supply of oxygen, and life in the de sea became possible for the first time. The have been many speculations as to ho a nearly uniform temperature could hav been brought about in sea-water over th whole surface of the earth in early geologica ages, as well as to how sufficient light coul have been present at the Poles to permit the luxuriant vegetation that once flouris in those regions. The explanation tha appears the most satisfactory is the on which attributes these conditions to th very much greater size of the sun in th early stages of the earth's history—an ide

first introduced into geological speculations by Blandet, who likewise discussed the relations of Arctic and Antarctic faunas together with the greater amount of aqueous vapour in the atmosphere and the greater mass of the atmosphere."

A comparison between the lives of land and sea plants is very instructive, and we may pursue it a little further. It will help to fix in our minds some of the great general biological principles it has been the object of these chapters to convey. We learnt in our early study how dependent is the animal world upon the vegetable for food supply, inasmuch as it is the plant alone which can convert the inorganic matter into the organic. Hence the enormous bulk of land plants. Now apply this to the conditions of sea plant and animal life, and a very interesting point emerges. The vegetables of the sea, so to speak, are only obvious along the coasts, and even here, as we have seen, the plants do not grow to any great depths. This somewhat scanty supply could not by any chance be adequate to maintain the enormous animal population of the sea, creatures which, for one thing, live far out at sea on the surface of the water, and, for another thing, also descend considerable distances out of the realm of sunlight. How is this disparity made up ?

PART OF A FROND OF BRITISH CORALLINE SHOWING STONY STRUCTURE

The answer is that it comes from the floating population of the sea, a population consisting of an enormous bulk of extremely minute plants, so minute that only the microscope reveals their nature, and only visible to the unaided eye when massed together in uncountable millions. Some of the more interesting and better-known members of this population must be mentioned, for they are among the most fascinating of the sea plants. First we have the *Diatomaceæ*, an immense group which numbers in it no less than some ten thousand different species inhabiting all the known waters of the earth. They have been studied in greater detail than most, partly on account of their wide distribution, and also, no doubt, on account of their fascination and beauty.

The diatoms are microscopic plants consisting of a single cell in each individual, the envelope of the cell being impregnated with silicious matter. Each individual has two shells which overlap each other, termed *valves*. The arrangement is like that of a box with an overlapping lid. They are coloured with chlorophyll and an additional brownish pigment, and many species are capable of movement. They reproduce themselves in a peculiar manner, by dividing into a successive number of partitions, each new generation being therefore smaller than the one preceding. Then they undergo a kind of spore formation, and the original size of the individual is regained. Like many microscopic forms of life, they sometimes adhere to each other in chains or masses, in the latter case being embedded in a viscous substance. Others live as independent unicellular plants. In the mass they look brown. The great beauty they present is especially due to the marvellous variety of the sculpturing which is seen on the shells, or valves.

Their movements, which are rapid, are always in the direction of backwards and forwards along the plane of their own long axis. It does not suggest the motion of an absolutely free organism swimming in the watery medium. It takes place along the

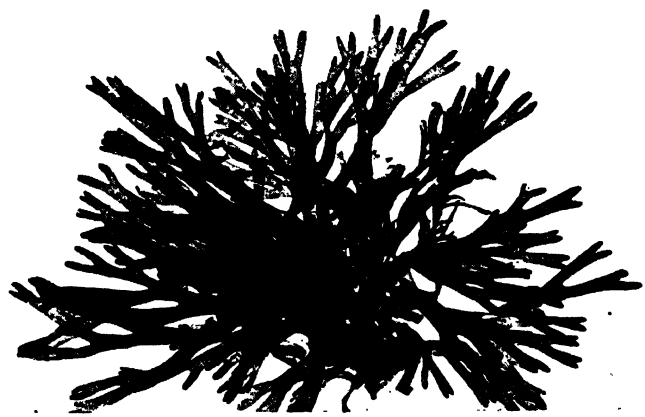
surface of whatever the diatom is resting upon, and is possibly due to the protrusion of cilia. "That these movements take place with considerable relative force is shown," says Mr. George Murray, "by the observation of Donkin, who saw one species push away another at least six times its size, while other observers state that they have seen this greatly exceeded. The speed of the movement when compared with the rapid dartings of ciliated organisms is slow. The Rev. Wm. Smith estimated the rate at about four hundred times a diatom's length in three minutes."

Although diatoms occur in untold numbers in the sea, and in all seas, they are most numerous in the chilly seas of the northern and southern oceans. When adherent in masses they form a "scum" on the water that has been examined when brought in by surface tow-nets. The individuals composing this mass of scum gradually die, and the silicious shells sink to the bottom of the sea, where they form the famous diatomaceous ooze. Ordinary fish, shell-fish, and the lobster and shrimp group, utilise diatoms as food, and there is no doubt that they constitute the most abundant vegetable food in sea water. They are preserved as fossils from tertian and quarternary times, and find a use in modern life in the well-known tripoli powder which consists of their shells. They are utilised in making dynamite.

Leaving these fascinating microscopic forms of plant life, we may look for a moment at some more familiar sea-weeds, such as may be found upon our own shores almost anywhere. The sea-weeds that can be most easily seen are naturally those which grow about the level of the tide when high, and amongst the most common of these are large, flat, green forms known as the *Ulvaceæ*. The mass of the plant, or the thallus, is irregular in outline, sometimes branched, and may be hollow, the space being between one or more layers of cells which have separated in growth. They are found all over the world, and even in fresh water. All the genera are found in our waters except one peculiar to Natal. They, above all sea-weeds, are responsible for the fouling of the bottoms of ships, producing what is termed "grass," by sea-going men.

CARRAGEEN, OR IRISH MOSS

Another group, the *Fucaceæ*, occur in all seas, but the species differ according to the temperature of their distribution. The thallus here is not so generalised as in some, and may present a distinct differentiation into such parts as stem, leaf, and root, if these terms are permissible in connection with sea-weeds. The layers of cells resemble those of land plants in suggesting an outer layer of epidermis, with parenchyma beneath, and a central portion which is like that of vascular bundles. The central strand passes along the plant into the stalk of the leaf, where it divides. The whole plant is attached at its root by a disc or sucker, or by special fibres still more



FORKED DICTYOTA

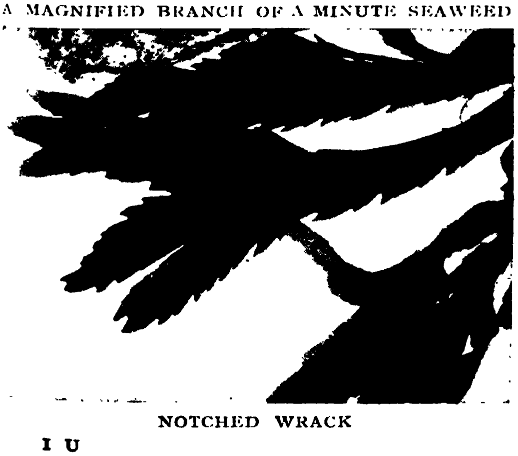
BROWN GRASSES OF THE GREAT SALT SEAS

CORRALINE

SEA-GRASS

A MAGNIFIED BRANCH OF A MINUTE SEAWEED

HALIDRYS, WITH A GROWTH OF SEA-FIR



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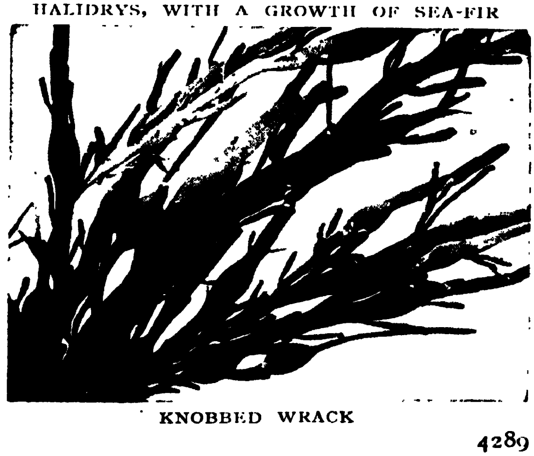


KNOBBED WRACK

suggestive of roots, and especially like the roots of parasitic plants. In some species special branches are set apart to carry the reproductive cells, or these may be on the ends of the leaves, or they may be dispersed over the mass of the plant. Where sexual cells are formed they are set free at ebb-tide as the result, in all probability, of the loss of water pressure, the cells uniting in the water when once more floated by the returning tide. Other forms are hermaphrodite.

Another group distributed in all seas, but especially in the North Atlantic, are the *Chordariaceæ*, which may be recognised from their slimy mass. Usually they are in the form of strands, covered with filaments.

Next we may note the widespread *Rhodophyceæ*, or red algæ, with varying shapes and sizes, ranging in colour from bright red to dull brown, and in appearance from filaments to flat bodies. One of them produces the well-known Ceylon moss from which is prepared a substance termed "agar-agar," which is of immense value to the bacteriologist. It has the property of solidifying liquids, in the same way as does gelatine, but agar-agar requires a far higher temperature than does gelatine to melt it, and hence can be utilised for growing such microbes as grow best at the temperature of the mammalian blood. A peculiar family of this group are the *Corallineæ*, easily recognised from the fact that the thallus is encrusted with lime salts, producing masses like stones. Some species grow along with true coral, and act as a cement by joining the corals together. Naturally they are brittle. Several species may be found on British shores.

MAGNIFIED TIP OF A FROND OF FEATHERY PTILOTA, A RED ALGA, SHOWING FRUITS ON ITS MARGIN

A remarkable group of sea plants called the Sea Grass must not be omitted. They resemble ordinary land plants much more closely than those already considered, especially in the fact that they have stems which dip down into the mud and are fixed by definite root fibres. From the stems there arise a number of extremely long, ribbon-like leaves, narrow and almost erect, being kept in position by the water. The grass wracks are found growing in large masses between the high and low tide levels. Many of the sea wracks are brown and leathery, and may be contracted into a stalk below, by means of which they attach themselves, widening out above into flat, leaf-like structures. Such are the Laminarias of the North Sea. It may be noted, in passing, that no matter how like a land plant a sea plant may be, it never develops true woody tissue, no matter what its size.

The sea plant remains stationary in its watery depths, or is swayed to and fro by the currents around it, but these do not tend to damage it, and no special contrivances are necessary to strengthen the plant, such as those we discussed in connection with trees of the forest. It is for this reason that aquatic plants, when brought into the open air, quickly collapse, their moisture evaporates readily, and, having no hard framework, their characteristic shape—and with it their beauty—

TANGLE OR FINGERED LAMINARIA LEFT EXPOSED UPON THE ROCKY SURFACE OF THE SEA-SHORE BY THE RECEDING TIDE

disappears. Their erect attitude in the water is assisted by the presence of air spaces in their tissues. The sea wracks do not shrivel up between low and high tides; they simply lie flat until the water returns, but they can only stand this exposure for a limited time. The largest sea wracks may grow to immense sizes, as much as from 300 to 900 feet in length, a prodigious growth comparable to the largest trees. It must be remembered, however, that these do not grow erect to this height, but grow at an angle towards the surface, taking the direction of the prevailing current.

FEATHERY PTILOTA—A RED ALGA

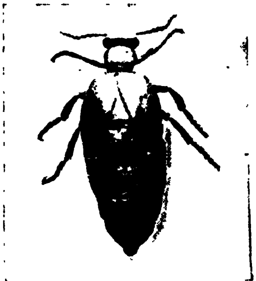
The careful reader, who has followed us through our study of the plant population, alike of the earth's surface and the ocean's depths, will, it is to be hoped, have realised that the great lesson to be learned, from a rapid glance at the main points of an enormous subject such as this, is that plant life, like all organic life, has been determined by the universal laws of Nature's selection and the survival of the fittest. Along these lines have been evolved all the marvellous adaptations for specialisation of function of which in the course of our studies we have seen so many striking examples.

SHELL ON SEA-FIR

FRUIT ON KNOTTED WRACK

SQUARE-TOPPED SEA-MAT

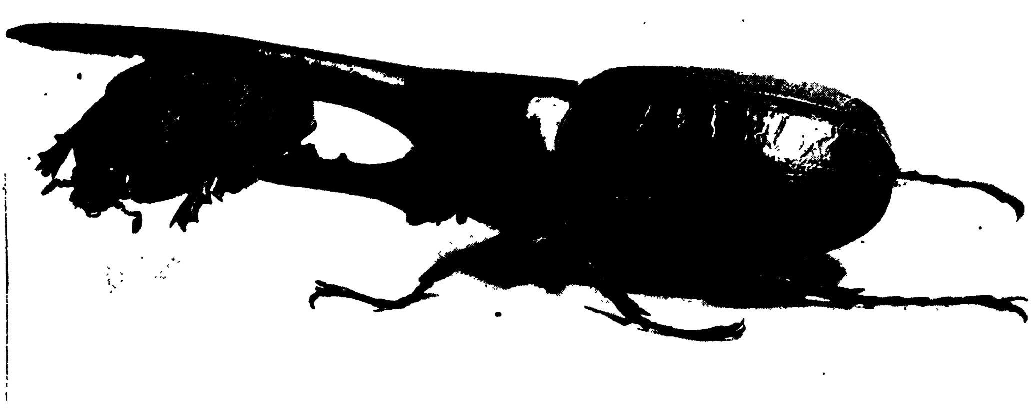
TYPICAL BEETLES FROM MANY LANDS



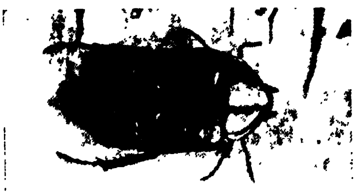
THE OIL BEETLE

STAG BEETLES FIGHTING

THE MUSK BEETLE



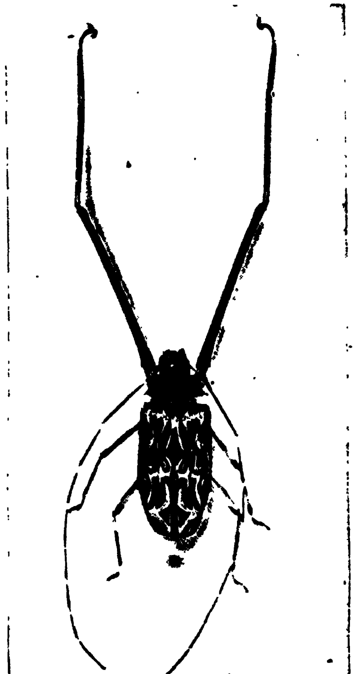
THE MALE HERCULES BEETLE OF SOUTH AMERICA CARRYING HIS MATE



THE ROSE BEETLE

THE DOR BEETLE

THE MEXICAN POLYPHYLLA



THE HARLEQUIN BEETLE

THE GOLIATH BEETLE

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INSECT AGAINST INSECT

The Vast Importance to Human Prosperity of the Trifling Things of Nature

ORGANISING THE BATTLE OF THE FLIES

THE time will come when the herd-books of the cattle-breeder, the records of the flock-master, and the stud-book of the horse-breeder will cease to be the sole official documents of the agriculturist. The day of the entomologist is at hand. He will police our fields and orchards, our forests and plantations, as the Home Office now polices our streets. We spend great sums in experimental agricultural stations, upon testing the relative values of fertilisers, upon creating new varieties of food growths, upon calling into existence new species of plant and flower and vegetable. We create with marvellous efficiency, but we do not effectively protect that which we create. In days to come the entomologist will be of as great importance to the community as the agricultural experimentalist of our generation has been.

He will deal with insects as Luther Burbank now deals with flowers and fruits and vegetables. He may not create new varieties, though, with the example of the poultry-breeder and master of flocks and herds before him, even this is not impossible. But undoubtedly he should be able to encourage the increase of beneficial insects, and to lessen the ravages of those that are harmful. If ants can nurture aphides, surely man can stimulate the multiplication of ichneumons, which destroy the ravaging aphides. The work has been begun in America, that first home of new causes. In certain areas they conserve and treasure the ladybird; and a farmer whose crops are infested with insects which form the food of these beneficent bugs calls at headquarters for a supply of ladybirds, just as in our own land a doctor calls for a supply of vaccine or diphtheria serum.

Practically every class of insects has its special parasites. The entomologist has to learn the life-history of each, and to encourage the beneficial class at the expense of the harmful class. The hard-headed farmer who now spends unsparingly on modern machinery, fertilisers, and germicides would laugh today if it were suggested that he should establish a stud of ichneumon wasps and carnivorous beetles upon his property. But before those of us who are now young grow old we shall see entomologists installed upon large properties, or in defined areas, just as now we see veterinary surgeons, farriers, and sanitary inspectors. It will prove a far better investment to pay the wages or fees of an entomologist to keep down pests than to sacrifice half a crop which it would be within his power to preserve almost in its entirety.

We have "tamed" the silkworm moth we have improved and almost domesticated the bee, we cultivate bacteria as freely as mustard and cress, we have farms for butterflies and moths. It remains to be seen whether the ingenuity of the scientist is sufficient to enable him to collect breeding supplies of ichneumons which will attack the plant lice, the destructive lepidoptera, the loathsome cockroach, and the larvæ of other harmful or offensive pests; the fungoid parasite which is fatal to the house-fly; and the many other known parasites friendly to man in so far as they are destructive of his enemies.

Entomology is still in its infancy; its votaries are regarded by the multitude as harmless eccentrics, as butterfly-chasers and pond-scavengers. The simple fact is that, limited as is their scope, the entomologists of the present-day world wield powers of almost incomparable importance. There is a parasite for almost every vegetable growth employed in manufacture or for food. Lancashire is at the mercy of various parasites of the cotton plant. The West Indies maintain their prosperity

only so long as they can keep in check the ravages of the banana parasite. Our leather merchants face panic prices in the event of a pest of warble-flies, which lay their eggs in the hide of the living cattle. The breeding of domestic animals is impossible in a great part of Africa until our entomologists can set a parasite to catch a fly. A mosquito for half a century prevented the building of the Panama Canal. Fruit, wheat, potatoes, and every kind of garden produce are menaced year by year by their several parasites; and though the man in the street hears nothing of it, skilled scientists are constantly at work, winter and summer, warring upon the pests which do the damage. We find evidence of their labours in unexpected quarters: one has but to glance in the Post Office Guide, at the restrictions upon the importation of plant life into European countries, to see how thoroughly the question has been explored officially.

Yet, in spite of all precautions, pests do spread. America sends them to Europe, and Europe sends hers to America. A pinch of eggs of the gypsy moth, which was an alien to the United States, resulted in such a crop of moths of that species as to cause America more loss in the course of years than any war in which she has ever been engaged. Upon the testimony of her Government experts, America still loses £100,000,000 every year through the damage done by insect life to her farm and garden crops. English losses are insignificant in comparison, from the fact that our producing area is smaller, but the damage done in relation to crops is very heavy.

A HOUSE-FLY KILLED BY FUNGUS

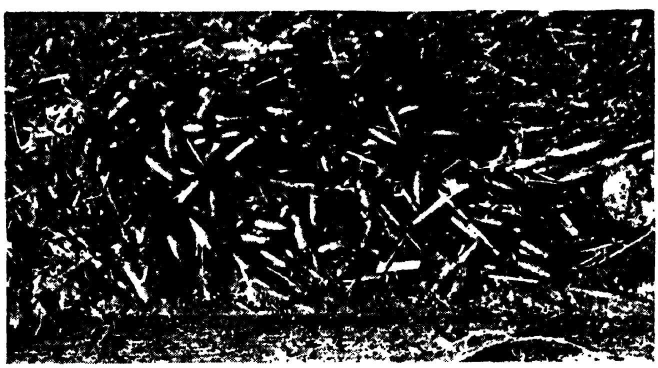
Take so inconsiderable a yield as black-currants. In 1905 English growers of this fruit sustained a loss of £250,000 through the havoc wrought by phytopus ribis, commonly known as the bud-mite. That is a concrete case, noted because the ill effects resulted from an epidemic of this particular pest. But there are other insect enemies always at work within the borders of the Empire. They destroy our forests, as they destroy the forests of other lands. They rob us of our all too scanty fruit; they run riot in the new lands of our oversea Britains. The Government finds it worth while to have entomological experts constantly on the move throughout the Empire, observing, learning—and teaching; while at home our Board of Agriculture issues warnings and instructions throughout the year concerning the affairs of our agriculturists and their insectile enemies.

Three examples come to mind of the way in which the entomologist goes to work for the benefit of his fellows. A shrewd and prosperous Kentish farmer noted that during one midsummer his fruit-trees were as bare of foliage as in midwinter. "Blight," was his comment. "Grubs," declared his son. "Rubbish!" retorted the father. The son, however, backed his theory in the autumn by plastering certain tree-trunks with treacle; and it was found that trees so treated bore good crops in the following year, while those not so protected failed as before. Closer observation followed, and in the treacle were found certain insects, which were sent to the Board of Agriculture entomologist. The son was right. The insects caught by the treacle were the wingless females of the destructive winter moth, which, completing their metamorphosis in the ground, must crawl up the tree. The males fly, of course. Now, the crawling female deposits her eggs in the branches of the tree, where the caterpillars are hatched to devour every green thing within reach. "Grease-band your trees, and the females cannot climb them, so your fruit will be saved," was the official advice. It was followed, and the farmer's orchards today are a picture of prosperity.

A second instance comes from South Dakota, where, owing to the enormous multiplication of bark-beetles, the destruction of pine-trees was reckoned at not less than a thousand million cubic feet of timber. At the beginning of an invasion the beetles attack only decaying or fallen trees, but when favourable conditions give the insects a good start, they gain energy, and become a veritable plague among the forest giants. All manner of devices were tried to check the invasion without effect. Trees were peeled, to expose the galleries of the larvæ; efforts to cut the affected timber were equally ineffectual. Suddenly there appeared a curious fungus upon the trees, which proved fatal to the beetles and their

larvæ. Man had not brought it there, but he observed its advent and effect, and forthwith was able artificially to increase its distributional range, and save his timber from the beetle.

The third instance is furnished by the Californian State Commissioners of Agriculture, who long sought, as we in this country have sought, to stay the ravages of the codlin moth. It is this moth which lays eggs in the blossom of the apple-tree, so that the grub becomes parasitic upon the apple itself, undergoing its metamorphosis within the living fruit, and eventually tunnelling its way out to complete its life cycle. An apple thus affected is not only disfigured, but never attains maturity. The least puff of wind suffices to dislodge it, and enormous quantities of spoilt fruit—"windfalls"—result. The Californian Commissioners assert that they have discovered the special parasite of the codlin. It is known as Ephialtes carbonarius, and attacks only this one species. By means of its long ovipositor drill it deposits its eggs within the body of the caterpillar. In that body the egg is hatched—or it may be a number of eggs; the larvæ feed upon the tissues of the living host, undergo all their changes within its body, and, after the chrysalis stage, emerge as fully developed flies, ready to carry on the good work for the protection of men's orchards. The discovery was no sooner made than the State authorities set to work to protect and encourage the development of this ichneumon; and five or six years ago they were hopeful that they would succeed in practically exterminating the codlin moth from the fruit-farms of California.



PUPÆ OF THE HOUSEFLY, BLUEBOTTLE, AND OTHER DISEASE-SPREADING FLIES UPON A MANURE HEAP

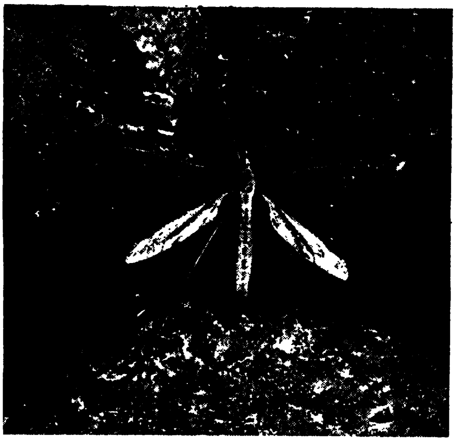
These ichneumons are truly marvellous allies of man. They number thousands of species, and assume an infinite variety of forms. Some are quite large, wasp-like creatures, but, unlike the wasp, they never hum; they approach with noiseless wings, as by stealth, to plunge their drill into the body of the victim with as little demonstration as possible. They are the cuckoos of the insect world, with the difference that whereas the young of the bird simply destroys the other young in its foster parents' nest, the larvæ of the ichneumon devour their host. Moreover, ichneumon will kill ichneumon, for some of the larger members of the clan treat the smaller species as the latter treat other insects.

We may thank the Microgaster glomeratus and the Pimpla instigator for the preservation of our cabbage gardens, for it is these two which assail the teeming larvæ of the cabbage butterfly. Our roses are saved for us by the Aphidus, which selects the hated greenfly for its cradle and larder in one. Our pine forests are policed by the Exenterus marginatorius, which preys in the manner indicated upon destructive pine sawflies. The voracious caterpillars of the hawkmoths are prevented from running their destructive course by species of the Banchus genus. The life histories of a vast number of the ichneumons have been worked out. We find their eggs, as we have seen, within the living bodies of other insect larvæ—as many as a thousand in the body of a single caterpillar; we find the insects marvellously locating larvæ hidden in the trunks of trees; they even have the audacity to plant their eggs within the eggs of other creatures—of spiders and beetles, for example.

Of flies which begin their lives within the eggs of other insects, the fairy-flies are the most fascinating little examples. We are indebted in the main for our knowledge on the subject to Mr. F. Enock, who has devoted over thirty years to his investigations, and, after the number of species known had stood for seventy years at thirty-five, has succeeded in discovering nine new genera and 150 new species. Each species of fly has its own particular host-egg, and Mr. Enock has known fifty-nine fairy-flies to emerge from one egg of a beetle. Some of the perfect flies are so small that they can walk five abreast through a hole in a card pierced by a pin. Of course, there are beetles and beetles, some of which we would not willingly surrender even to the wonderful little fairy-fly; but there is one

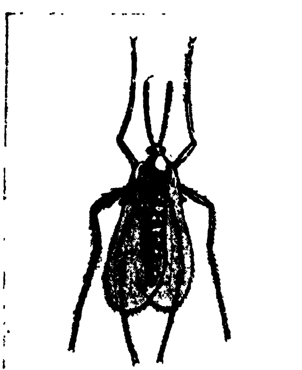
misnamed "beetle," the cockroach, that we should all be glad to make over to the javelin wasp, which is known to deposit its own eggs within the singular egg-capsule of this loathsome house-pest.

Not every insect which possesses an ovipositor drill is an ichneumon, of course. We find instruments of this description possessed by the gall-wasps or gall-flies. Exactly how they produce the curious galls, upon oak and rose and so forth, we do not at present know.

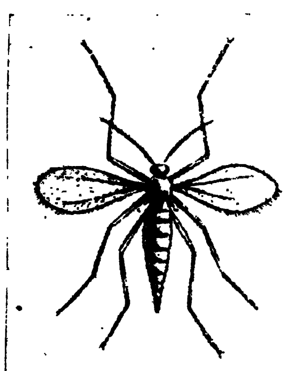


CRANE-FLY, WITH OVIPOSITOR EXTENDED FOR DEPOSITING EGGS

It is no longer believed that the secretion poured into the wound made by the drill alone suffices. The fluid itself is supposed to act primarily as an adhesive security to retain the egg on the selected spot, and it is thought that the gall results from the after-effects—the wound, the presence of the eggs, the movements of the larvæ within the wound, and the action of a fluid secreted by the larvæ themselves, all tending to produce the strange modifications of cell-structure which manifest themselves in the various galls. Some such galls, it is needless to remark, have considerable economic importance, notably that of the ink-gall of the Levantine oak.



HESSIAN FLY



BRITISH WHEAT-MIDGE

These insects constitute a study to themselves, their reproductive relations being especially curious and interesting.

Passing on to the Diptera, we have here an order of two-winged insects. Formerly the members of the order were four-winged, but the second, or hind, pair of wings have become vestigial, and act now merely as balancers. How these perform their function it is difficult to say, but certain it is that a fly with its balancers removed loses all power of maintaining its equilibrium. This question of wings brings us to the buzz of the fly. It is commonly supposed that the sound proceeds from the wings alone, but there are two sounds—the first from the wings, the second from the exceedingly rapid vibrations of the thorax. The latter produce the higher note that we hear when a blowfly is seized. That note is due to the fact that the vibrations of the thorax reach some thirteen hundred per second, while those of the wings are just half that number.

The life story of the flies and mosquitoes has already been so fully treated in preceding chapters of this work that it would only duplicate the information to enter at length upon it here. One or two salient points may, however, be noted. The blowfly lays its eggs in flesh, not necessarily dead flesh, for cases have been noted in which wounds, and even the nostrils of a sleeping man, have been selected. The domestic fly, of which we are cursed with three species, breeds in filth and corruption. It is a mistake to suppose that the small flies that we see are young flies. They are adult examples of their species. Houseflies are born from maggots, in horse-dung. There they undergo their larval and pupal stages, and emerge fully developed flies. How they carry corruption and infection has been shown on page 3557 and succeeding pages. Before man became a sanitarian the fly may have served a purpose as a scavenger; but as now it flits from its noxious feast straight to the food that he eats, and the milk that he and his children drink, the following figures, published by Dr. L. O. Howard, in his impressive volume on the subject, assume a specially sinister aspect.

Beginning on April 15 with an over-wintering fly, which on that date laid 120 eggs, he arrives at the following table,

postulating that all eggs and all individual flies survive, and allowing ten days to a generation in summer.

April 15 : The female lays 120 eggs.

May 1 : 120 adults issue, of which 60 are females.

May 10 : 60 females each lay 120 eggs.

May 28 : 7200 adults issue, of which 3600 are females.

June 8 : 3600 females each lay 120 eggs.

THE COCKCHAFER IN FLIGHT

June 20 : 432,000 adults issue, of which 216,000 are females.

June 30 : 216,000 females each lay 120 eggs.

The table continues in this manner on to September 10, when 5,598,720,000,000 adults issue, of which one half are females.

Of course, not nearly all the eggs or adults survive, but the table is illuminating as showing the terrible potentialities for increase possessed by a single fertilised female fly. There would be no lamentation on the score of extinction of a species should the last housefly perish. A well-known public man, who is deeply concerned with the problem of child life in a busy northern city, lays it down as a business proposition that it pays that city better to provide the children of the poor with sterilised milk at the cost of the ratepayers than to meet the cost of funerals of poor children killed by fly-infected milk.

A BRAZILIAN BEETLE ROLLING A BALL

The story of the gnats and mosquitoes has already been told, and need not be recapitulated, nor a word added to the tragic history of their death-dealing actions against man. Gnats and mosquitoes, be it noted, are one and the same, but midges, although allied to the others, are distinct. Although the hateful little black midge that bites at night rather gives the lie to the general statement, it is a fact that midges, taking the majority, do not bite, for the reason, that they lack any blood-drawing apparatus. A curious thing has been observed of an Asian relative of our common plumed midge (Chironomous plumosus).

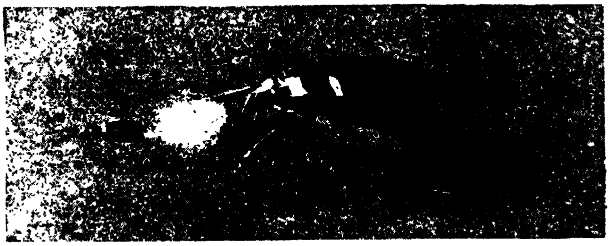
THE GREAT GADFLY

Vast numbers of these insects frequenting the shores of Lake Issyk-kul were found to be brightly luminous. The light emitted was due to the presence in the insects of multitudes of parasitic bacteria, whose presence prevented their hosts from rising on the wing. Now, there is another true midge, Ceroplatus sesioides, which is luminous from natural internal mechanism, as in the case of the glow-worm, but here the light proceeds from the whole body of the insect, and is given off by both sexes.

The gall-midges are quite another group, and, with the so-called Hessian fly at their head, do incalculable damage to crops when in the larval stage. In this group we find an extraordinary case of reproduction by the larvæ. The gall midge in question is Miastor metroloas. During the summer reproduction follows the normal course, but, when colder weather sets in, the larvæ, which dwell under the bark of trees, develop living young within their bodies. These devour the vitals of the parent ; then emerge, and themselves give birth to a generation in similar manner, and so the phenomenon continues until warm weather

permits the life cycle to follow the extraordinarily unusual course.

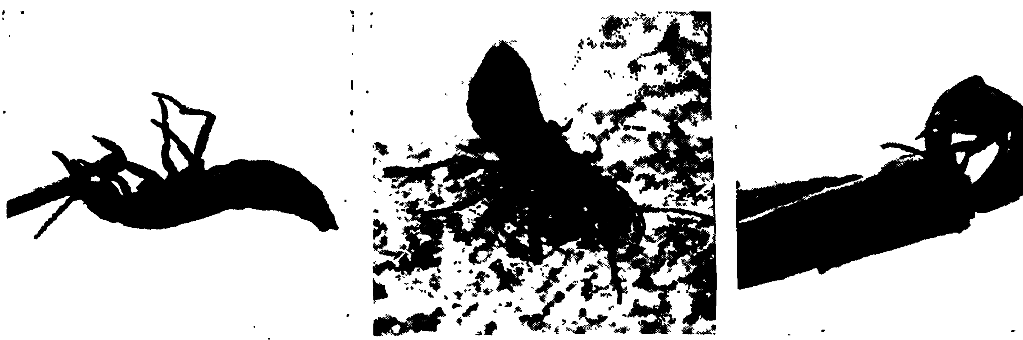
The sandflies which follow are among the most venomous of our enemies. Minute, difficult to discover, they have always been among the most dreaded of insects; but since pellagra has been traced to their bite the detestation in which they are held is increased a hundredfold. Pellagra is a disease which runs its course in the human system during a long series of years, finally producing insanity and death. Millions of persons are affected by it, and its cause has been a mystery until the last two years, when research work carried out by a brilliant London professor revealed the unsuspected origin. How to grapple with the myriad insects from whose bite the disease arises is a matter which has yet to be demonstrated on a wide scale. These and the deadly tsetse-fly, whose malevolent work has already been traced in another section of this work, are among the enemies to human life whose detection we owe primarily to the man who studies insects. If these and their like can be checked, or rendered innocuous and the "if" is a mighty one—lands or parts of lands which are now simply death-traps may become numbered with the most flourishing places of the earth.



A BOMBARDIER BEETLE REPELLING A CARNIVOROUS BEETLE BY THE EJECTION OF ACID

But even among the flies which do not cause death we have enemies capable of great damage to commerce. Among these are the various bot-flies. Gastrophilus equi is a plague to horses, although its larvæ, which eventually find their way into the quadruped's alimentary system, do the animal no harm, so far as has been ascertained. The ox-bot, or warble-fly, however is a most pernicious insect; and cattle view it with instinctive dread, galloping from it in terror as the fly seeks to deposit its eggs upon their hide. Milk supply and flesh are thus injured, but the greatest damage results after the deposition of the eggs. The maggots which result eat their way through the hide and cause a small tumour where they remain for nearly a year. As many as four hundred maggots of this fly have been known to issue from the skin of a single beast. The animal is tortured by the suppurating tumour and loses flesh and condition, and its hide is greatly deteriorated in value. A careful estimate puts the loss to the leather trade from the warble-flies in Great Britain alone at something like £8,000,000 a year.

The sheep bot-fly is another formidable pest, and, numerous in genera and species and widely distributed, infests mammals of many kinds—including, on the evidence of two cases, man himself—and birds and even amphibians. The forest-flies are another strange group parasitic upon horses and cattle, which they bite upon those parts of the body least protected with hair. Some of the species attack birds; one species is parasitic upon deer. Beginning their career as winged insects, these insects bite off their wings on settling upon their hosts after the manner of a queen-ant newly returned from her wedding trip.



THE TENACITY AND FEROCITY OF THE DEVIL'S COACH-HORSE BEETLE IN ATTACK

In the forest-flies we find a remarkable method of development. Only a single

young one is born at a time, and this, instead of being produced in the egg stage, remains within the body of the parent, nourished at her expense by means analogous to those which obtain in the higher mammals. When born, the young is either actually a pupa, or at once assumes the pupal form, being motionless, without segmentation, and enclosed in a horny case.

elephant-beetle, the goliath, and the titan, six inches in length and proportionately broad. Beetles play an important part in the daily affairs of the world. While we have, on the one hand, weevils destroying manufactured food, and hosts of other species taking toll of trees and growing crops, there are still more numerous hosts getting their living as scavengers and as

THE WATER-BEETLE SWIMMING, IN PUPA FORM, AND FLYING

snappers-up of innumerable other insects harmful to man. We find them boring deep into wood, living and dead. Their presence in dead wood has given rise to one of the most distressing of all the superstitions that go to make life unhappy. Because a minute beetle (Anobium) bangs his horny little head upon the woodwork of the furniture or other timber in which he has made his home, knocking to attract the attention of his ladylove, the credulous call the sound the death-tick. Many an hour of deadly terror has been experienced in the silence of the sick-room when the signals of this innocent, if destructive, beetle have been heard. The present writer was confirmed in his zeal for entomology when the true history of the death-watch beetle was first made plain to his youthful mind, and the agony of fear into which acceptance of this oft-repeated abomination of superstition had plunged it with regard to this little invader of the ancient furniture of the home, was dispelled. We have a fine brigade of carnivorous ground-beetles, and many interesting examples among them, none more so, perhaps, than the bombardier and

Fleas are only aberrant flies. They have no wings, but are descended from the ancestral stock from which the flies arose. The evil part that they play in the transmission of disease has already been shown. For the sake of those who do not leave our own shores, it may be repeated that the flea is frequently the first host of the larvæ of a tapeworm. The ova are expelled from the body of dog or cat; they are swallowed by the flea, which in turn is eaten by the dog or cat, in whose interior the life cycle begins again. Hence, if cats and dogs are kept about a house, they should be treated with the greatest care to prevent their harbouring both the internal and the external parasites.

MOLE-CRICKETS IN THEIR BURROWS

We can give but brief notice to the beetles, or coleoptera, of which huge division some 130,000 different species have been described, while fully as many more, it is surmised, await the observer. There is a life's work here for the student, and a fascinating work, too. Greater diversity of form and habit it would be difficult to find in the realm of animate Nature. We have beetles minute as the smallest pinhead, and, at the other end of the scale, examples such as the

his allies, which, when apprehensive of attack, audibly eject with explosive force a fluid which volatises, upon emission, into smoke. Another notable example of the carabidæ is the violin-beetle, whose name is bestowed in relation to its singular shape. Next in order come the carnivorous water-beetles, of which the dytiscidæ, the great water-beetles of our ponds and ditches, are familiar and shining examples.

nivorous. The inveterate enemy of cate pillars and other insect larvæ, they ea vegetable refuse as well as slugs and snails The gardener has scarcely a better inse friend than this little, sombre beetle wit the truculent fighting postures. Th carrion beetles proper include the burying beetles, which, attracted to the dead bod of bird or small mammal, dig away the so beneath the carcase and gradually lowe

THE LARGE GREEN GRASSHOPPER

THE HOUSE-CRICKET

Well as we all know them, it seems hard to realise that these insects, so perfectly adapted to aquatic life, are notable fliers. Passing nine-tenths of their time deep down in the water, thanks to their method of carrying down a bubble of air at a time, to be absorbed by means of abdominal and thoracic spiracles, they can at will rise into the air and fly across half a county in search of new quarters. You have but to dig a pool in your garden to be sure of finding water-beetles there in due season; or closely to examine the tank in your greenhouse; you will not be disappointed. Equally common, though infinitely more attractive because of the brave show that they make on the surface of the water, are the whirligig beetles. These appear to have a stronger homing sense than the greater beetles, for of hundreds that the present writer has carried to his home, he has never succeeded in establishing a permanent stock. You may put them on the water today, but if the circumstances do not suit them they will be off again at night, though ponds near by always teem with them.

THE ENGLISH CICADA

Although they are carrion feeders, the rove-beetles are not included among the carrion beetles proper. The roves, prominent among which is our admirable devil's coach-horse, are practically om-

the latter until it is covered with soi earth. Then the female lays her eggs i the body, and the larvæ, when hatche devour the flesh.

Of destructive beetles there is a lon list, but the museum-beetle and allie (Dermestidæ) demand a place in ou section, for in the larval form they wor havoc with natural history exhibits, bot furs, skins, and dried insects, beside causing great damage in the home to fur- and also to hair-padde furniture.

The adaptability c some of the beetle trib is indeed remarkabl One, Lasioderma serr corne, has given itse over to the consumptio of cigars; a second ha invaded the cigarett box, while a third ha become known as th drug-room beetle. Thi (Sitodrepa panicla) is desperate fellow, waxin fat on chemicals stron enough to poison a army. It is impossible to put it on wrong diet, for it seems immune to al ordinary known poisons; the one pla feasible is to fumigate the parcel or bale o drugs which constitutes the wooden hor by means of which this most insidious fo invades the chemist's Troy.

Our next group comprises the stag-beetl and allies, whose larvæ pass years in th timber of oak-trees before attaining th

perfect form. The writer possesses one, of nearly the full three inches, which he caught in this wise. The beetle flew drowsily, humming overhead one summer evening, too high for net to reach. It passed apparently to safety, when lo, a blackbird, abandoning a tussle with a home-loving worm, popped up from the tennis lawn and seized the new-comer. The writer followed hot-foot, frightened off the bird, secured the beetle, sought in vain to get it to feed, and today he has it among his little treasures that possess a history. Large as are the stag-beetles, they are small compared with the larger members of the Lamellicornia, comprising the monsters to which reference has already been made. In this group we find some common British species, such as the dumble-dor or shard-born beetles, and the chafers.

In concluding our mention of the beetles, two more varieties alone can be named. The first are the oil-beetles. In these the larvæ display an almost incomparable instinct for gaining a living When hatched they are active little things, and climb without difficulty the stems of flowers, where they calmly await the arrival of a bee. When Brer Rabbit made a " riding hoss " of Brer Fox, he was but taking a leaf out of the book of these little creatures. For the oil-beetle larva, as soon as a bee comes its way, takes a firm hold of the honey-spinner's hair, and so rides away to the hive, where it diets itself upon the eggs of the bee, afterwards undergoing two stages of development and subsisting upon the choicest honey of the hive.

The last group is restricted to the Stylopidæ, or parasitic beetles. These are not to be confounded with Claviger testaceus, which makes its home in ant-hills ; for the Stylopidæ live actually in the bodies of their hosts—bees, wasps and bugs. Here the female lays her eggs, from which emerge active little six-legged larvæ. These, quitting the depleted living storehouse in which they have hatched, complete their growth in the body of some new host. The male develops into a smart little winged beetle, but the female never advances beyond the grub-like condition, eyeless, wingless, and limbless.

A WALKING LEAF INSECT

Reference has been made to the value of ladybirds, in devouring aphides and plant-lice, and attention may be drawn to the interesting life stories of the ant-lion, the caddis-fly, and the stone-flies. These lead us on to the true orthoptera, in which we find such insects as the crickets, grasshoppers, the dreaded locusts, the famous leaf and stick insects, the praying insects, or Mantidæ, the earwigs and the hateful cockroach. This is a highly important group. Whereas the very mention of locust suffices to send a shiver of apprehension through one who hears it in a land where its ravages have once been experienced, we have in the leaf and stick insects two of the most famous examples of adaptation to surroundings, which do not occasion any such dread. In South Africa locusts periodically appear in as great hosts as ever. One swarm that passed over Pretoria in 1891 was estimated to be twenty-five miles long, one and a half miles broad, and half a mile in depth. Nobody attempted to estimate their numbers. In 1907 an observer in Johannesburg made a sort of effort in regard to a locust-storm that passed over the Rand. The swarm darkened the sky, made the white mountains brown, broke down the telephone wires by their weight, stopped the railway service by making the lines impassable, caused trams to run away downhill on the slippery metals, filled the

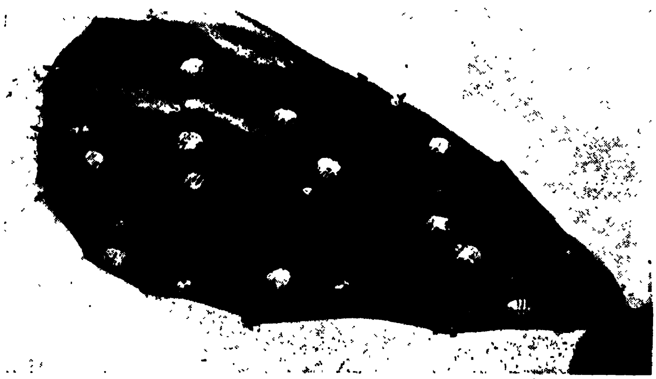
THE PRAYING MANTIS

streets, the houses, the gardens, and ate up every green thing. And this was only a small detachment of the whole. The observer declared that the whole world appeared to be filled with locusts.

Many methods have been tried to exterminate these pests, with varying success. A fungoid parasite has been experimented with in parts of America. Arsenic spraying, "locust screens" for catching the wingless larvæ, destruction of the eggs, rolling the infested ground with heavy rollers, have all done their share in the work. But Africa is a continent with many different governmental systems; and locusts, exterminated in British territory swarm again in, say, Portuguese territory, to despoil the face of the land elsewhere. It is disheartening to find that, after all the efforts made, locusts in a recent year appeared in such multitudes that one swarm took ten days to pass a given spot, and a second took twenty-one days. The entomologist can conquer the locust, but he can only do so by the co-operation of men as skilled and assiduous over a wide area.

AN EARWIG EATING A DAHLIA LEAF

There are many other destructive insects, such as plant lice, which include the aphides and the phylloxera, the deadly enemy of the vine; the cicadas, known as the seventeen year locust, since that period elapses between one generation of the winged insects and another; leaf-fleas, which puncture and drain leaves and buds of plant, and shrubs and trees; and scale, of which one species, Icerya purchasi, accidentally imported into America from Australia, threatened the entire orange plantations of California with ruin. Came the entomologists to the rescue. They went to Australia, studied the life history of the pest on the spot, found that its natural enemies were certain dipterous and hymenopterous parasites, but chiefly the lady-bird; imported and bred these, and cleared their orchards of the deadly peril.



COCHINEAL INSECTS ON THE LEAF OF AN OPUNTIA

In the Coccidæ (scale insects), however, are numbered some of service to man notably the cochineal insects which are, or until the discovery of synthetic dyes were, assiduously "cultivated" for their yield of colouring matter. The lac insect, from which we get lac dye and shellac, is another of the beneficial scale insects. There remain familiar parasitic insects such as those infesting the human and other mammalian body, but this is not the place for a dissertation on these revolting intruders. They, with other parasitic forms of life by which the careless, indifferent, or uncleanly are affected, may best be studied in the text-book.

Our review of the insect world is necessarily indicative rather than categorical, but it may serve to direct the student to a closer investigation of a subject teeming with vital interest to the life and commerce of the world. Certainly no other branch of Nature-study offers so wide a field for investigation, and none other presents such challenging problems today. The advance of civilisation into fair lands of promise is absolutely dominated at this hour by insects. Flies are mightier than all the armies of the Great Powers; mosquitoes more puissant and terrible than the combined artillery of the world; and certain beetles, moths, and other insects are more costly to the food and revenue of man than the sum expended on all the military forces in existence. With work of such infinite possibilities before them, we need not wonder that the patriarchs among our entomologists dream dreams, and that their sons see visions

OUR PERSONAL DESTINY

The Testimony of the Human Spirit to Our Persistence and Continued Identity

IF A MAN DIE, SHALL HE LIVE AGAIN?

THE last and immeasurably the most difficult problem of all is now before us. In other sections of this work, the questions of the future of life upon our planet, and of the future possibilities of the human species, are considered. They are difficult enough, and yet we have a mass of tangible and concrete data which help us to form conclusions upon them. The problem before us now is of another order. It is not enough for us to know that our species may survive for long ages to come, nor to recognise that form of immortality which is possibly conveyed by parenthood. The Weismannian theory of the individual as the transient trustee of the immortal race is doubtless a portion of the truth; but, when all such questions have been discussed, the man of today, like his predecessors in all times and places, asks the question, "Shall I all die?"

Upon the belief in some form of personal survival have been based all the great religions of the world. There are, no doubt, religious possibilities apart from such belief. The Sadducees denied a resurrection. Modern Positivism is concerned wholly with this world; and modern Christianity almost daily becomes more concerned with human life here and now. Nevertheless, the belief in human survival is an *almost* essential ingredient of religion, and the vast majority of religious people would feel that they had nothing left without it. Further, apart from any special creed or practice, we have the deepest interest in this question, first, as regards ourselves, and, second, as regards the possibility of meeting again those whom we have loved and lost—or who are "not lost, but gone before."

For some persons no evidence of personal survival, in the ordinary sense, is required, and the fact is worthy of note. Such persons are content to do without the older kind of supposed evidence to which we shall soon refer, and also to do without the newer evidence which a certain number of patient students of today are endeavouring to amass. For these people this is a matter of intuition; no access of knowledge or science from without is required, no authoritative teaching, no personal experiences even. They simply feel that they cannot all die, that their loved ones cannot die; and this conviction, whatever its internal origin and measure of validity, suffices for them. The fact that such people exist is, of course, a fact of and for science, and must therefore be recorded. Future psychological study must attempt to define and explain the manner in which these people feel differently from the rest of mankind.

For very many of us no intuition, nor feeling of personal conviction, varying markedly, perhaps, from time to time, is enough. We demand some kind of knowledge, in the ordinary sense of the word, as experience, as verified fact, which can be recorded and interpreted, and is valid not merely for a single person but for all who will accept the rules of evidence and of scientific reasoning on other subjects. Let us, then, look at the history of our knowledge, or supposed knowledge, of this subject, and observe how the opinion of the most thoughtful of mankind has varied from time to time.

We are not here concerned with belief in an after-life, inculcated in the name and with the authority of religion. But we are concerned with the facts, or supposed facts, which were regarded as proofs of the survival of the dead in past times. According to the celebrated theory of Herbert Spencer, the so-called supernatural religions had their origin in dreams. In dreams we see the dead, and therefore

we have evidence that the dead survive. We see them as they lived, we hear their voices as they spoke, and thus we have direct evidence of an after-life. Hence, on this theory of the origin of religion, it may be concluded not only that the dead survive, but that, from our dream-knowledge of them, they are near us, still interested in us, and *able to affect us*. Therefore it will be well to be on good terms with them, and especially with those, such as departed chiefs, who were powerful during their earthly lives. Hence the systematic worship of the dead, and the countless ages during which mankind has suffered grievously, as Herbert Spencer points out with the utmost force and truth, from "the sacrifice of the living to the dead."

The Impossibility of Science Accepting Dreams as Proofs of Personal Survival

The beautiful and affecting sonnet written by the blind Milton on the dream in which he saw his departed wife, and ending with the poignant words "and day brought back my night," expresses more clearly, perhaps, than anything else in the recorded experience of mankind the sense of absolute demonstration which such dreams may convey to their subjects. The man who has had such a dream of any dead person, and who accepts its validity, will not trouble himself much about "Psychical Research" and the kind of evidence which it affords. But such dreams cannot be accepted by science as proof of personal survival. It is scarcely necessary here to state the reasons why science must reject such evidence—not that science has any right to form a decision as to the truth or the basis of such rejection. Simply the fact is that we know too much about the nature and untrustworthiness of dreams in general to accept them as evidence. But there may be cases where dreams and hallucinations can be proved to correspond to real events unknown by any ordinary means to the percipient. Such dreams and hallucinations may be conveniently called *veridical*, or truth-telling. They must be studied carefully, for they suggest psychical possibilities of immense importance which bear upon the problem of personal survival.

The Importance of the Factor of Chance in Dreams

It is obvious that the factor called chance has to be reckoned with. There are many people asleep every night, and many dreams are dreamt. The laws of chance suggest that a proportion of these dreams will turn out to be true. If a woman of nervous and loving disposition dreams frequently that her absent husband or son is ill or dying or dead, she may prove to be right at last, and the fact may be recorded as noteworthy, though the further fact that she had been wrong on many previous occasions may be forgotten. This, of course, is not an unreasonable objection but a necessary one which must be met before the demands of science are satisfied. Our object is not to prove that such and such is true. That is the object of the advocate; the man of science is only concerned to find the truth, whatever it be. All evidence must be examined, and every possible interpretation must be considered. We follow this plan when we refuse to admit as final the ordinary evidence of bodily death and dissolution, and when we say that this does not prove what it appears to prove. So also we must question the evidence on the other side and the importance of the factor of chance coincidence must be recognised.

Sir Oliver Lodge's Acceptance of "Phantasms of the Dying" as Proved

In our study of what is technically called telepathy, or thought-transference, we confined ourselves to the experimental evidence of the actual passage of ideas from one mind to another, under experimental conditions. But if we enlarge the definition of the term we shall require, and do now require, to consider other kinds of influence of one mind upon another—not under experimental conditions, and not exactly the transference of thoughts, yet much more important than anything which the experiments elsewhere discussed could show. There is, indeed, no end to the carefully and honourably recorded and well-attested cases of apparitions, or phantasms, seen by friends or relatives at or near the time of death. Many readers will have had personal experiences of this kind, or could cite cases known to them. Sir Oliver Lodge has reached the following conclusion as to the great body of evidence which the Society for Psychical Research has been able to collect during many past years.

"'Phantasms of the dying' might be a better name for these very numerous cases of apparition or veridical hallucination. Whatever the cause the fact of their existence has been thoroughly established; there is a concordance far beyond chance between apparitions which convey the impression of the unexpected death or illness of a distant person and the actual fact, the intelligence being, in this form, impressed on a percipient at a distance

by some unconscious mental activity, and by means at present unknown.".

Though instances of this kind are so numerous that any attempt to state the evidence of them here would be absurd, yet we may quote a single case, by no means the most striking of those collected by the Society for Psychical Research, as an illustration which will serve to make more definite in the reader's mind the type of experience which we have here considered.

A Case on which the Society for Physical Research Relies

This is "the case of a favourite and devoted Scottish workman who appeared to his employer in what is described as an extraordinarily vivid dream, in which the workman appeared with a face of 'indescribable bluish pale colour, and on his forehead spots like blots of sweat,' and earnestly said several times that he had not done the thing which he was accused of doing. When asked what this was, he replied impressively, 'Ye'll sune ken.' Almost immediately afterwards the news of this man's suicide arrived. But the employer felt assured on the strength of his vision that, though dead, the man had not committed suicide, and said so. Before long it turned out that his assurance was correct, for the workman had drunk from a bottle containing nitric acid, by accident. The employer, moreover, subsequently ascertained that the symptoms exhibited by the phantasmal appearance were such as are appropriate to poisoning by this liquid."

We thus have passed from the ancient evidence, credited by most of mankind for long ages, to modern evidence which is really of the same order. The dream, or "vision," and what is seen therein, may be wholly misleading as evidence of facts, and no man of science can accept it.

The Tremendous Scientific Case for Personal Survival

We cannot regard dreams of the dead as a proof of their survival, in the manner which satisfied the makers of primitive religion on Herbert Spencer's theory. But we have to return to dreams and study them afresh when we find that in certain cases they are "veridical," and the conclusion which we reach, though it does not amount to proof of personal survival, is a tremendous one. Under certain conditions, such as those associated with death, imminent *or recent*, mind can communicate to mind in a fashion beyond our understanding. On this evidence, telepathy, in the widest sense of the word, must be regarded as a fact, and we feel that we are a step nearer the solution of the great problem of personal survival. The words "or recent" have just been italicised for their importance in this connection. These visions sometimes follow so long after the hour of death that they must be classed as phantasms neither of the living nor of the dying, but of the dead. And in such cases we have to ask how much these phantasms demonstrate.

Let us now take up the greatest contribution to this subject yet made, F. W. H. Myers's "Human Personality and Its Survival of Bodily Death," the volume from which we learnt so much regarding the nature of genius. Twelve years have now passed since the death of the author, early in 1901. The attitude of the scientific world has greatly changed in that comparatively short period. It may be described as one of true "scepticism," which is *search*, and no longer one of contemptuous denial.

The Scientific Change of Attitude since Myers Discussed Survival After Death

In the preface to his book, Myers wrote—

"Even now I write in full consciousness of the low value commonly attached to inquiries of the kind which I pursue. Even now a book on such a subject must still expect to evoke, not only legitimate criticism of many kinds, but also much of that disgust and resentment which novelty and heterodoxy naturally excite. But I have no wish to exalt into a deed of daring an enterprise which to the next generation must seem the most obvious thing in the world."

The next generation has scarcely yet arrived, but already Myers's words are justified. It does now seem "the most obvious thing in the world" that the facts obtained by psychical research should be presented and considered as a whole for their bearing upon the problem of human survival. Of these facts Myers said, "In future years the wonder, I think, will be that their announcement was so largely left to a writer with leisure so scanty, and with scientific equipment so incomplete." And here we may agree, in astonishment that the professed students of the mind should have left this task to an amateur; but we need not regret the fact, for Myers had the finest endowment in the world for the work which he set himself to do.

Myers began by commenting upon the remarkable fact that "man has never yet applied to the problems which most profoundly concern him those methods of inquiry which, in attacking all other

problems, he has found the most efficacious. The question for man most momentous of all is whether or no he has an immortal soul; or—to avoid the word *immortal*, which belongs to the realm of infinities—whether or no his personality involves any element which can survive bodily death. In this direction have always lain the gravest fears, the farthest-reaching hopes, which could either oppress or stimulate mortal minds.

Myers's Contention that Science has Overlooked the Science of the Soul

"On the other hand, the method which our race has found most effective in acquiring knowledge is by this time familiar to all men. It is the method of modern Science—that process which consists in an interrogation of Nature entirely dispassionate, patient, systematic; such careful experiment and cumulative record as can often elicit from her slightest indications her deepest truths. That method is now dominant throughout the civilised world, and although in many directions experiments may be difficult and dubious, facts rare and elusive, Science works slowly on and bides her time—refusing to fall back upon tradition or to launch into speculation, merely because strait is the gate which leads to valid discovery, indisputable truth. I say, then, that this method has never yet been applied to the all-important problem of the existence, the powers, the destiny of the human soul."

Here is a very remarkable statement, which is, nevertheless, perfectly true. Posterity will say that in our own time, thanks to such pioneers as Myers, *the science of the soul* was founded, and already some results are at hand. Many pages later, near the end of his introduction, Myers describes what may now be called his celebrated analogy between certain inquiries in physics and certain of his own inquiries and conclusions in what might with propriety be called psychics.

An Effective Suggested Parallelism Between Physics and Psychics

The student of sunlight has made certain wonderful discoveries. The visible white light which we know so well can be split up by the prism into a band, or spectrum, of various coloured rays, on either side of which is darkness. But further inquiry shows that, in Myers's own words, "the limits of our spectrum do not inhere in the sun that shines, but in the eye that marks his shining. Beyond each end of that prismatic ribbon are ether-waves of which our retina takes no cognisance. Beyond the red end come waves whose potency we still recognise, but as heat and not as light. Beyond the violet end are waves still more mysterious, whose very existence man for ages never suspected, and whose intimate potencies are still but obscurely known. Even thus, I venture to affirm, beyond each end of our conscious spectrum extends a range of faculty and perception, exceeding the known range, but as yet indistinctly guessed. The artifices of the modern physicist have extended far in each direction the visible spectrum known to Newton. It is for the modern psychologist to discover artifices which may extend in each direction the conscious spectrum as known to Plato or to Kant. . . . Something of clearness will be gained by even this rudimentary mental picture, representing conscious human faculty as a linear spectrum whose red rays begin where voluntary muscular control and organic sensation begin, and whose violet rays fade away at the point at which man's highest strain of imagination verges into reverie or esctasy."

Is There a Prolongation of Processes Beyond Our Power of Observation?

"At both ends of this spectrum I believe that our evidence indicates a momentous prolongation. Beyond the *red* end, of course, we already know that vital faculty of some kind must needs extend. We know that organic processes are constantly taking place within us which are not subject to our control, but which make the very foundation of our physical being. We know that the habitual limits of our voluntary action can be far extended under the influence of strong excitement. It need not surprise us to find that appropriate artifices—hypnotism, or self-suggestion—can carry the power of our will over our organism to a yet further point."

"The faculties that lie beyond the *violet* end of our psychological spectrum will need more delicate exhibition and will command a less ready belief. The actinic energy which lies beyond the violet end of the solar spectrum is less obviously influential in our material world than is the dark heat which lies beyond the red end. Even so, one may say, the influence of the ultra-intellectual or supernormal faculties upon our welfare as terrene organisms is less marked in common life than the influence of the organic or subnormal faculties. Yet it is *that* prolongation of our spectrum upon which our gaze will need to be most strenuously fixed. It is *there* that we shall find

our inquiry opening upon a cosmic prospect and inciting us upon an endless way."

It would be impertinent to apologise for such a long quotation, or for these concluding sentences from this magnificent introduction, in which the author defines his "main purpose."

"That purpose was, above all, to show that realms left thus far to philosophy or to religion—too often to mere superstition and idle dream—might in the end be brought under steady scientific rule. I contend that Religion and Science are no separable or independent provinces of thought or action, but rather that each name implies a different aspect of the same ideal, that ideal being the completely normal reaction of the individual spirit to the whole of cosmic law. Assuredly this deepening response of man's spirit to the Cosmos deepening round him must be affected by all the signals which now are glimmering out of night to tell him of his inmost nature and his endless fate. Who can think that either Science or Revelation has spoken as yet more than a first half-comprehended word?"

The Return of the Soul to the Realm of Science

It is well that our previous studies in this section have prepared us for our final inquiry, at any rate as far as the first assumption is concerned. Any inquiry as to the survival of personality would be futile if science had satisfied us that in fact there is no such thing as a personality to survive. If man is merely a machine, the working of which occasionally produces the "epi-phenomenon" or "phosphorescence" or "by-product" called consciousness, then no question as to the survival of that phosphorescence can arise. It is for the student of the individual human being, as we observe him in life, to say whether or not it is necessary to assert the existence of any psychical unity which exists in the body, or even, perhaps, made and uses the body. If our study of physiology and psychology requires no such assumption, and if we assent to such a view of man as was maintained by the representative materialists of the nineteenth century, and has recently been exhumed by Professor Schäfer today, we cannot be expected to proceed with Myers's inquiry at all.

But the reader will easily be able to recall or refer to certain parts of our study in which it appeared impossible to understand or even to state the facts without the idea of a psychical something, complex yet single, as the body is, which we found ourselves compelled to call the soul. In our survey of what we had learnt regarding the various senses of man, outer and inner, we found that "the soul returns" to the realm of science, whence a less developed science had sought to expel it. And still later, after the study of will and self-control, we found ourselves faced with the old question "What is Man?" and no other answer than "A living Soul" was possible. We believe, therefore, that we have scientific warrant for proceeding with our inquiry as to the survival of what science now requires to recognise; and this is precisely where the modern reader of Myers's book differs from a similar reader at, say, the time of Myers's death.

The Acceptance of Myers's Theory of a Disintegration of Personality

No one who has read his Bergson, no one who is aware of the new developments in the study of insanity which we owe to the reintroduction of the idea of the personality into that field, can fail to feel that Myers is treading on assured scientific ground when he begins, as he does, by studying "the disintegrations of personality." Such a phrase, a decade ago, was looked upon as something altogether outside science. We could understand disintegration of the brain, but not of the personality—*that* was a mere "*façon de parler*." Today we re-read this chaper with some remembrance of the work of Professor Freud, of Vienna, and the proof that many phenomena of insanity can only be understood and defined in this very phrase, "disintegrations of personality," which Myers employed.

The Individual Life of the Cell and the Unity of the Central Life

The nature of human personality, as understood by Myers, and as now understood by such great psychologists and alienists as we have lately named, is "at once profoundly unitary and infinitely complex." Each of us inherits from earthly and animal ancestors a multiplex and "colonial" organism, with many little "animal" lives and many little "cell-souls" in it, as Haeckel would say. And, according to Myers, this organism is ruled and unified by "a soul or spirit absolutely beyond our present analysis—a soul which has originated in a spiritual or metethereal—*i.e.*, beyond-the-ether—environment, which even while embodied subsists in that environment, and which will still subsist therein after the body's decay." Myers goes on to meet, very justly, the evident difficulty,

and shows that it is there in any case, as we have already repeatedly seen.

"It is, of course, impossible for us to picture to ourselves the way in which the individual life of each cell of the body is reconciled with the unity of the central life which controls the body as a whole. But this difficulty is not created or intensified by the hypothesis of a separate and persistent soul. On no hypothesis can we really understand the collaboration and subordination of the cell-lives of any multicellular animal. It is as mysterious in the starfish as it is in Plato . . . as inconceivable as the life of the phagocytes in the philosopher's veins, in their relation to his central thought. I claim, in fact, that the ancient hypothesis of an indwelling soul, possessing and using the body as a whole, yet bearing a real though obscure relation to the various more or less apparently disparate conscious groupings manifested in connection with the organism and in connection with more or less localised groups of nerve-matter, is an hypothesis not more perplexing, not more cumbrous, than any other hypothesis yet suggested. I claim also that it is conceivably provable—I myself hold it as actually proved—by direct observation."

The Need for Scientific Investigation and Differentiation

The kind of proof which Myers thought he had, and which psychical research must long continue to study, is that of the order suggested by the phrase "phantasms of the dead." As he himself said, "In popular parlance, we are looking out for *ghosts*." But he went on to show, as every man of science or philosopher must show, how puerile and impossible is the popular idea of a ghost as "a deceased person permitted by Providence to hold communication with survivors." What we must look for, rather, may be defined as a "manifestation of persistent personal energy." Such a manifestation would be, for instance, an apparition, or phantasm, of a dead person; and the reader will at once see how close we are again to the evidence of what we know to be entirely baseless dreams. The difficult but essential task is to distinguish the cases, if any there be, where the phantasm can in some way demonstrate its actuality as a psychical influence, persisting and acting from without upon the percipient's mind.

This is a matter of evidence, which cannot be abbreviated. All we can say here is that large quantities of material exist. Myers's chapter is a mere summary. There is also the whole mass of evidence contained in the Proceedings of the Society for Psychical Research. The reader who desires to do justice to the question must give himself to the long and difficult task of studying this evidence, and much besides. All we can do here is to give the references, and to observe, in the name of science, that the lover of truth will refrain from giving a verdict until he has studied the evidence—and very probably even then. Unfortunately, the great majority, even of men of science in various of its fields, take an attitude which was described long ago in the words "neither would they be persuaded though one rose from the dead."

The Reasonable Attitude of Scientific Scepticism Against Sensation-loving Ignorance

Their attitude is not so unreasonable as it sounds. Their scientific knowledge teaches them the great law of the continuity and uniformity of Nature. They are rightly outraged at the complete defiance and denial and ignorance of the modes of Nature's working which are displayed by the claims usually advanced for the spiritual world. Something which the popular mind desires, "outside Law and above Nature," is just what the man of science distrusts.

Myers, and those who worked with and after him in the Society for Psychical Research, such as Professor W. F. Barrett and Sir Oliver Lodge, start differently, and the man of science is bound to take a very different attitude towards them. In Myers's admirable words, "Believing that all cognisable Mind is as continuous as all cognisable Matter, my ideal would be to attempt for the realm of mind what the spectroscope and the law of gravitation have effected for the realm of matter, and to carry that known cosmic uniformity of substance and introduction upwards among the essences and operations of an unknown spiritual world."

The Profound and Attractive Philosphy of Frederic Myers

If what we call science is worth prosecuting it is worth prosecuting here. Those who have not looked closely at any department of knowledge always underestimate its value. To the layman, nearly everything that the astronomer, the geologist, the chemist, the physiologist inquire into is trivial or pointless; but they know better. The case is the same here, with the question of man's survival of death, on which Myers argued as follows—

"It is in itself a definite problem, admitting of conceivable proof which even if not

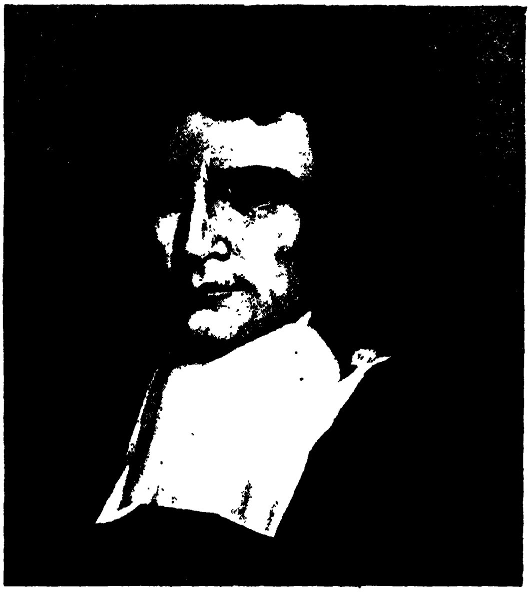
technically vigorous, might amply satisfy the scientific mind. And at the same time the conception which it involves is in itself a kind of avenue and inlet into infinity. Could a proof of our survival be obtained, it would carry us deeper into the true nature of the universe than we should be carried by an even perfect knowledge of the material scheme of things.

"It would carry us deeper both by achievement and by promise. The discovery that there was a life in man independent of blood and brain would be a cardinal, a domineering fact in all science and in all philosophy. And the prospect thus opened to human knowledge, in this or in other worlds, would be limitless indeed."

One last quotation from this profound pioneer—and even so we have left all his statements in poetic form on one side.

"The high possibilities that lie before us should be grasped once for all, in order that the dignity of the quest may help the inquirer through many disappointments, deceptions, and delays. But he must remember that this inquiry must be extended over many generations, nor must he allow himself to be persuaded that there are byways to mastery. I will not say that there cannot possibly be any such thing as occult wisdom, or dominion over the secrets of Nature ascetically or magically acquired. But I will say that every claim of this kind which my colleagues or I have been able to examine has proved deserving of complete mistrust, and that we have no confidence here, any more than elsewhere, in any methods except the open, candid, straightforward methods which the spirit of modern science demands.

"All omens point towards the steady continuance of just such labour as has already taught us all we know. Perhaps, indeed, in this complex of interpenetrating spirits our own effort is no individual, no transitory thing. That which lies at the root of each of us lies at the root of the Cosmos, too. Our struggle is the struggle of the Universe itself, and the very Godhead finds fulfilment through our upward-striving souls."



BARUCH SPINOZA

We leave Myers with this great last paragraph, because it brings his underlying philosophy so closely into line with that of the contemporary thinker, Professor Bergson, whose aid has been invaluable to us throughout our study. When Myers says, "Our own effort is no individual, no transitory thing," every reader of Bergson must recognise the identity of thought with that which we find at the end of the French philosopher's masterly chapter on "The Meaning of Evolution." For Bergson, life is psychical; it is Mind at bottom. There is in all Life a push, or "*élan vital*," which, as Myers would say, shows itself at its highest "through our upward-striving souls." Here are the last sentences of Bergson's chapter, for comparison and consideration:

"We feel ourselves no longer isolated in humanity, humanity no longer seems isolated in the nature that it dominates . . . All organised beings, from the humblest to the highest, from the first origins of life to the time in which we are, and in all places as in all times, do but evidence a single impulsion, the inverse of the movement of matter, and in itself indivisible. All the living hold together, and all yield to the same tremendous push. The animal takes its stand on the plant, man bestrides animality, and the whole of humanity, in space and in time, is one immense army galloping beside and before and behind each of us in an overwhelming charge, able to beat down resistance and clear the most formidable obstacles, perhaps even death."

It need hardly be said that thinkers of this order cannot be successfully treated in a few words; the reader must refer for himself to, especially, the latter pages of this chapter of Bergson's "Creative Evolution" (Chap. III). Myers was not acquainted with Bergson, and the Frenchman nowhere refers to Myers; but we have here seen the

alliance between their reasoning, and their conclusions, reached by very different routes. Briefly, we may summarise Bergson's further statements on this question as follows—"The distance is infinite between the animal and the man." "The life of the body is on the road that leads to the life of the spirit." "Souls are continually being created, which, nevertheless, in a certain sense pre-existed. They are nothing else than the little rills into which the great river of life divides itself, flowing through the body of humanity." "Consciousness is distinct from the organism it animates, though it must undergo its vicissitudes."

A Contrast Between the Hesitancy of Science and the Assurance of Religion

And, finally, though consciousness and brain are interdependent, "the destiny of consciousness is not bound up on that account with the destiny of cerebral matter." Much less is the destiny of the *whole* of the mind, of which consciousness is only a part, as the visible spectrum is only a part of the solar radiation.

The reader must be acutely conscious of the contrast between these deepest and most authoritative voices of contemporary thought, and the confident and detailed assurance of much religious teaching for ages past on this subject. Bergson's "perhaps even death" is a long way from "a sure and certain hope of a glorious resurrection." But the thinkers must not be blamed for that loyalty to the Truth *as they see it*, which allows them to assert no more than they regard as proved or provable. More knowledge will bring more detail and assurance of statement; and those who value and honour the processes of science and logic, the toil which they involve, and the peculiar conviction which they may yield, will be slow to underrate, on account of their inadequacy, such statements as those we have cited from Myers and Bergson.

The Unanimity and Warmth of the Testimony of Profound Thinkers

Not that profound and genuine thinking may not be found elsewhere, leading to statements as positive and jubilant as the heart of man can desire. For them we must go to such philosophers as Plato and Spinoza, Greek and Jew, far removed in place and time, and to the long line of poets from Homer to Walt Whitman. The unanimity of their testimony is amazing to the student of what great and sober men have thought; and such unanimity, from such men, acknowledged by universal consent to be the seers and the inspired of our race, is a *datum* for Science to recognise and appraise. Instances are without end; to be a great poet, it would seem, is to believe, from knowledge and experience of Man, that the human soul is divine and immortal. Thus Virgil, two thousand years ago, wrote—the translation is by Myers—

To God again the enfranchised soul must tend,
He is her home, her Author is her end;
No death is hers; when earthly eyes grow dim
Starlike she soars and Godlike melts in Him

—which is just what Wordsworth wrote in another clime, with a wholly different set of "religious" beliefs, long centuries later—

That Man, who is from God sent forth,
Doth yet again to God return;
Such ebb and flow must ever be.
Then wherefore should we mourn?

Plato and Spinoza were far apart, agreeing only in that they thought deeply; and if Virgil and Wordsworth were so too, the same is true of Wordsworth and Walt Whitman in our own time. In his recognition of science, in his rejection of traditional beliefs, Whitman was a poet whom science may well seek to study.

Walt Whitman's Testimony to the Survival and Ascent of the Soul

From first to last he sang "the eternal Soul." And, like Myers and Bergson, he believed, not merely that the soul survives, but greatest possibility of all that it *ascends*. Creative Evolution, the *élan* of life, persists in it. The change at death, he says, will be as from breathing water, in "the world below the brine," to breathing air. Like Myers, he teaches that death drops the rubbish "I will make the true poem of riches, to earn for the body and the mind whatever adheres, and is not dropt by Death." For him, Death is "Passage to more than India;" thus

O my brave Soul,
O farther, farther sail.
O daring joy, but safe! Are they not all the seas of God?
O farther, farther, farther sail.

And thus—

Joy! shipmate—joy!
(Pleas'd to my Soul at death I cry:)
Our life is closed—our life begins;
The long, long anchorage we leave,
The ship is clear at last—she leaps!
She swiftly courses from the shore;
Joy, shipmate—joy!

OUR SELF-MADE SICKNESSES

The Ultimate Dependence of Individual and Public Health on Private Conduct

WHAT HEALTH INSURANCE CANNOT DO

In the preceding chapters of this section we have dealt with the laws of health, as they may be observed by and for individuals - men, women, and children. We need still to consider a matter of the very first importance, which receives too little recognition at the present day. It is the relation of the private observance of these laws to the health of the community in general. For the student and advocate of personal hygiene, as we have attempted to discuss it in this section, now requires to make a most serious protest on behalf of his subject, and against the contemporary tendency to believe that a man's private conduct in matters of hygiene is only his own affair, and that sanitary laws and sickness provisions from without can make the individuals of a nation healthy and cure them when they are ill.

If we refer to the risks of recent legislation in this respect, our object is not to decry such legislation, or to question its utility. Only we need to point out that the factor of personal conduct retains, and must always retain, its importance for the health of a nation, no matter what legislative provisions may be made.

The nation has recently brought into operation the most comprehensive and expensive measure for the service of individual health that has ever been put upon the Statute Book, or even so much as contemplated in this country. The Insurance Act is, in the main, a measure designed for the health of a large proportion of the individuals who constitute the nation. In part, it is a measure for financial relief in cases of illness, and that does not here concern us. But mainly it is hoped and designed to be, as its title declares, a measure "for the prevention of sickness"—that is to say, for the maintenance of health. In connection with our study of personal hygiene, it becomes an urgent necessity to consider the influence of this measure, which is designed to maintain and to restore the health of many millions of the workers of the community. We have to ask how far this measure, or any measure, can effect its end unaided, and how far it requires the intelligent and responsible co-operation of the insured.

If the laws of health upon which we have spent so much time be valid, the simplest legislative measure "for the prevention of sickness" would be one which somehow imposed the observance of those laws upon everybody. That is not feasible, but the question for us is how far we may not require that, somehow or other, the private conduct of individuals shall conform to the laws of health, if, indeed, we are all to pay and to suffer for the consequences of their infraction.

Briefly, we may dispose of two portions of the Act which are subsidiary, though of great importance. As regards "maternity benefit," we recognise a monetary provision which should certainly make for individual health on a national scale. Further, if our study of the conditions of health in infancy and childhood be sound, maternity benefit should now be promoting the present and future health of many very young individuals, by helping to provide them with the right kind of nourishment in the earliest and most important weeks of their lives.

But, even in the case of maternity benefit, which is generally admitted to be the best and soundest part of the Act, the factor of private conduct must be considered. The infant, indeed, can only receive what happens to it, but the parents retain their wills and their choice. When these words are written, the *details* of administration of maternity benefit are entirely unconsidered.

But the writer is aware of expectant mothers in certain northern colliery villages who mortgaged their maternity benefits, and there is general knowledge as to the husbands and fathers who, having the benefit paid in cash to them, will be sure to see that it becomes a publican's benefit. The point we here desire to make is that public and national health cannot be attained by the provision of money, even for the most essential and desirable ends, unless private conduct of the right kind controls its expenditure.

The Sound Hygienic Principle of the Sanatorium Benefit

Secondly, let us consider the sanatorium benefit as a means for obtaining national health, and freedom from the most deadly of all diseases. Here, again, we have, in unprecedented fashion, the nation's recognition of the fact that the health of individuals is an object upon which the nation's income may be spent. In one vitally important respect, the hygienist can only approve unreservedly of the new provisions. This is an infection, and every infection involves questions of national and personal conduct. In this case, the infectious person is not infrequently unable to protect others from the infection, or to protect himself from reinfection. Under these conditions, where private conduct cannot effect what is necessary, the State undertakes the public duty of removing the individual from the conditions in which others are exceedingly liable to contract the disease from him. This is the universally admitted principle in regard to, for instance, typhus and diphtheria, where it is idle to discuss the "laws of health for men, women, and children," so long as they remain within range of the infection. So far as all infections are concerned, our duty is to isolate them, and discuss any questions of private conduct in matters of diet and so forth afterwards, if necessary.

The Effects of Sanatoria in Influencing Private Conduct

So far, excellent; but the hygienist would be neglecting a duty if he did not observe that private conduct is inextricably concerned in the problem of dealing with consumption. In one respect, the public provision of sanatoria will effect an improvement in private conduct, for every consumptive will learn, at the sanatoria, some of those laws of health which it was omitted to teach him at school, and which will help him to protect himself and others. The consumptive will be taught that he must not spit indiscriminately, but into something that can be destroyed or sterilised, and that thus he will protect himself and others from future infection. He will be, and is being, taught to keep bedroom windows open, to take moderate open-air exercise, to avoid foul atmospheres, to take no alcohol, not to keep late hours, to sleep in a room by himself, and so forth. All of these are matters of private conduct, and the value of sanatoria, other than as mere leper-houses for the isolation of infection, will chiefly depend upon the extent to which they thus modify the private conduct of those who pass through them. The theory that a sanatorium can cure, and confer immunity for the future against the modes of conduct which originally produced the disease, is an absurd one directly it is so stated, though many advocates of sanatorium benefit seem to entertain it. As much as this could be claimed for no sanatorium in any case.

Private Conduct the Most Important Factor of all in the Treatment of Consumption

There will be many patients in whom the sanatorium arrests the disease, and in whom, if they spent the rest of their lives under sanatorium conditions, the disease would never reassert itself; but the patients will not be kept in sanatoria for the rest of their lives, and the question is, how far will they maintain sanatorium conditions after their discharge? The reader may say that this is obviously impossible, and so it is in some respects. But those respects are not the most important, though popular and even professional opinion assumes that they are. It is not the beautiful surroundings, the light and the air of the sanatorium, that do the most good. That was the old view, when it was thought that to build a sanatorium in a pine forest was to give the patient antiseptic odours to breathe, which would cure him. The modern sanatorium physician knows that the regimen of the sanatorium is important above all. It is the regular life, the graduated exercise, liberating small doses of the bacilli, which the defensive forces of the body can successively destroy; the abundant, well-digested, well-chosen diet, and the absence of alcohol that matter most.

Cases now abound where sanatorium treatment has been carried out at home. No pine forest odours, nor even ordinary country air, have been employed, but the patient has lived the right kind of life at home. If the place has been disinfected, and if he is careful with the expectoration—which will

shortly cease to be produced, very probably —he runs no chance of infecting himself or others, and the regimen can be practised anywhere. Every student of tuberculosis knows that these are the conclusions towards which those engaged in treating the disease have been coming for several years past. In a word, they mean that private conduct is the most important factor of all in the treatment of the disease, and that, as has been forcibly said, "No fool can be cured of consumption."

Individual Care for Health the True Secret of Prevention

If this be true of the treatment of the disease, how much more true must it not be of its prevention? The hygienist is surely entitled to ask this question when he reads the provisions of an Act "for the prevention of sickness," under which millions of pounds are to be spent annually upon one disease alone, but in which not one word is said as to the private conduct of the insured in relation to the prevention of that disease. It is the entire blindness of Parliament, of the friendly societies, and of the insured themselves, to the importance of personal behaviour in relation to consumption that requires the hygienist, with all the force at his command, to point to the facts which pathology and therapeutics have discovered. In this disease it is the laws of health for individuals that matter supremely. The observance of those laws, which we have already discussed at length, and have commended for the healthy who wish to remain healthy, is exactly what the sanatorium enjoins, effects, and succeeds by effecting. The laws of health indicate the importance of open air, right exercise, wise diet, avoidance of poisons. We have spent months in their discussion here. But it is just these simple, familiar laws that the sanatorium enjoins upon the consumptive; nothing more, no marvellous novelties, only the old principle, "wash and be clean."

The Expenditure of Public Money Ineffective Without Healthy Conduct

The hygienist is therefore bound to state that, if the Insurance Act is to succeed in its project of the prevention of sickness, notably in relation to tuberculosis, something will have to be done about the private conduct of the insured. No man can be maintained in health against his will. In our cities, where tubercle bacilli exist in large numbers in certain places, the man who prepares the soil in the right way, and then allows the seed to be sown, will reap the fruit, with a rich supply of further seed to spread broadcast for others. Every honest student of this subject is compelled to risk unpopularity, and the resentment of many individuals, and to declare that no expenditure of public money will eradicate tuberculosis unless the private conduct of individuals conforms to the laws of health, which are the laws of immunity from this disease.

Those who solicit and live by the suffrages of the people feel a natural delicacy in alluding to the fact that democracy does not mean the absence of rule, and the superfluity of all discipline. The notion that people can only save themselves, in the long run, is often an inconvenient one to quote. But it is eminently true in matters of health. Legislation and sanitation can do much. They can require notification of infectious diseases, and can proceed to isolate them. In the case of consumption that notification is now required in this country, and since February 1, 1913, there has been in force an order of the Local Government Board for England and Wales that all forms of tuberculosis, and not the pulmonary form alone, shall be notified.

The Difference Between Disease that Hurts Only the Individual, and Disease that Spreads

Legislation can lay down regulations as to the provision of light and air in private dwellings, shops, and factories, and it may enforce precautions as to the contamination of milk with tubercle bacilli, but it cannot effectively help those who will not help themselves. So long as tubercle bacilli are to be encountered at all, personal conduct will retain its importance as a factor in immunity or susceptibility. When there are no more such bacilli to encounter, people may do as they please, so far as this disease is concerned, but other and appropriate penalties will be duly exacted from them.

If a man chooses persistently to strain his heart by violent exercise for which it is unequal, and so acquires heart disease due to his own conduct, the disease is at any rate confined to himself. He is no danger to his neighbours, though they lose the value of his work, and may pay for his illness. But the private conduct of the man who contracts tuberculosis of the lungs is in another category. Not merely may he become an economic burden—he becomes a purveyor of disease. In the case of several other diseases we act promptly and without respect of persons. In the case of this disease, we cannot or do not, owing to its frequency and its chronicity. Thus the consumptive is specially liable to be a danger to others, by means of his expec-

toration. Now, we have already admitted that a law which should abolish the disease by enjoining hygienic conduct on everybody is an impossibility; but at least the law should make it a punishable offence to spread this disease, or any other, by spitting. This is a dangerous and offensive practice which can be stopped, and from the hour in which Koch found the tubercle bacillus in the sputum of consumptives it has become a cardinal necessity to control spitting if we wish to prevent this disease. It is to be feared that, only in so far as it isolates a proportion of cases, does the Insurance Act effectively deal even with this single and manageable aspect of private conduct.

The Close Association Between Alcoholism and the Prevalence of Consumption

The importance of alcohol in relation to tuberculosis has been discussed elsewhere in this work. Let us observe how closely it concerns us when we make a national effort to get rid of the disease. The fight against tuberculosis, said the International Congress on Tuberculosis a few years ago, must everywhere be combined with the fight against alcoholism. Such pronouncements lend much force to the contentions of such authorities as Sir Victor Horsley and Sir Alfred Pearce Gould, that a Licensing Act is required in order to make feasible the projects of the Insurance Act, especially when we recall the evidence produced by many medical officers of health to show that the public-house is a great centre of tuberculous infection, in virtue of the bacillary contents of its floor and its dust. But even here, while controversy proceeds upon such legislative questions, the advocate of personal hygiene is entitled to point out that, even in the absence of Licensing Acts, and in the presence of public-houses, a man need not take alcohol—unless he has already become a victim to the habit. The importance of personal conduct remains, and will remain, whatever Licensing Acts be put upon the Statute Book in the future.

The Failure of the Insurance Act to Teach that Temperance Drives Off Disease

The Insurance Act, while seeking to control consumption, makes almost no attempt to modify the private conduct of the insured in the direction which increases their resistance to the disease. The simple principle of the Act is that money will heal, and save, and prevent. But the time has come when something must be done, by public authority, to modify personal conduct in the direction of hygiene. The Insurance Act does propose to pay for an undefined number of lectures upon the principles of health, and those lectures will, of course, include the discussion of the kind of private conduct which enables a man to resist tuberculosis or to throw it off Temperance lectures, among others, have been mentioned by Mr. Lloyd George as liable to be given under the provisions of the Act, apparently only in places where the rate of sickness is supposed to be excessive. But far more than this is needed, and examples may be already cited. About a decade ago, for instance, a very remarkable manifesto was placarded officially in various parts of Paris, upon the post-offices, upon the outside wall of the Hôtel de Ville, and upon the hospitals. A few paragraphs from this document may be cited.

"Alcoholism is chronic poisoning resulting from the habitual use of alcohol, even when this is not taken in amounts sufficient to produce drunkenness.

"It is an error to state that alcohol is necessary for workmen who are engaged in arduous manual labour, that it gives energy for work, or that it renews strength. The artificial excitement which it produces quickly gives place to nervous depression and weakness; in truth, alcohol is useful to nobody; it is harmful to all.

A French Official Warning Against Alcoholism that was Checkmated by Business

"The habit of drinking spirits leads quickly to alcoholism, but the so-called hygienic drinks also contain alcohol; the only difference is one of quantity; the man who daily drinks an immoderate quantity of wine, of cider, or beer becomes as surely alcoholic as the one who drinks brandy.

"The habit of drinking leads to neglect of family, to forgetfulness of all social duties, to distaste for work, to want, theft, and crime. It leads, at the very least, to the hospital, for alcoholism causes a great variety of diseases, many of them most deadly: paralysis, insanity, disorders of the stomach and of the liver, dropsy; it is one of the most frequent causes of consumption. Finally, it complicates and renders more serious every acute illness; a typhoid fever, pneumonia, or erysipelas, which would be mild in a sober individual, will rapidly kill the alcoholic. Alcoholism is one of the most frightful scourges, whether it be regarded from the point of view of the health of the individual, or the existence of the family, or of the future of the country."

It only remains to add that the vendors of alcohol in Paris rose up against this manifesto, which was thereupon removed from nearly all the places where it had been

AN INCIDENT IN THE SANATORIUM WORK CURE OF A LADY PATIENT

A PHASE OF THE OPEN-AIR WORK-CURE IN A SANATORIUM FOR MEN

affixed. Meanwhile, a decade later, we may observe that, in Paris, the consumption of alcohol, and the incidence of tuberculosis, are slowly but steadily rising. In this country the most notable attempt to follow and to better the example of Paris has lately been made by the Corporation of the city of Sheffield. In and by this great city there has been issued an official poster, signed by the Lord Mayor, the Medical Officer of Health, and the Town Clerk; and as this document is a model of its kind, especially for a city where the love of active sports is great, we reproduce it here.

An English Official Poster that might be Used in Education

This is a moderate and carefully compiled statement, which certainly goes no farther than the Syllabus of Instruction in Hygiene and Temperance, which was issued recently by the Board of Education for the guidance of teachers giving lessons in those subjects. The authorised publication of this poster helps Sheffield to maintain, in regard to matters of health, and notably of tuberculosis, the position which it has long held—notably as regards the compulsory notification of consumption, for which Sheffield had an Act to itself years before the Local Government Board made this compulsory everywhere. It is to be hoped that the example of Sheffield will be followed by other municipalities everywhere. It is also to be hoped that education authorities everywhere, realising their duty to teach the laws of life as well as the laws of grammar, will give lessons in hygiene and temperance, according to the official syllabus. The giving of such lessons at all is at present optional, and there are many education authorities which are not doing their obvious duty in this matter. Yet sound teaching at school as to the importance of private conduct in matters of health would surely do something towards making possible the "prevention of sickness" among the industrial population.

How the Wise Pay Public Health-Money for the Folly of the Foolish

According to the Insurance Act, the insured person whose illness is due to his own fault is to receive medical benefit, but not sickness benefit. We can only wonder what the distribution of sickness benefit would amount to if this clause were really to be administered according to the knowledge of the physiologist and the hygienist. Every doctor in ordinary practice knows the immense importance of private conduct in the production of illness and incapacity for work. If the doctor tells the whole truth frankly, and advises accordingly, the patient will depart in search of another practitioner who "understands his case." The public does not hear the whole truth about its responsibility for its own ailments. The Insurance Act will be interpreted to mean that a man may not receive sickness benefit when his illness is due to one or other of the diseases which are commonly looked upon as shameful. Apart from those diseases, no doubt sickness benefit will be freely paid; but we have only to inquire into the facts in order to discover that, indeed, the wise will be steadily paying, under this Act, for the folly of the foolish, whose claims for benefits will depend upon their own fault, though no one will incriminate them for it.

The authoritative statement on the public health aspect of the part of private conduct which is concerned with alcohol is to be found in the chapter, "The Influence of the Drinking of Alcoholic Beverages on the National Health," contributed by Dr. Arthur Newsholme to Sir Victor Horsley's and Dr. Mary Sturge's book, "Alcohol and the Human Body."

The Enormous Health Advantage of the Total Abstainer

Here we can only give the reference to that overwhelming paper. But it deals almost wholly with the influence of alcohol upon the death-rate. So far as we are concerned with the maintenance of health as against sickness, and with the Insurance Act, which is not concerned with death, but with the state of health during life, we need, in addition to common experience, some evidence as to the extent of sickness due to alcoholism, and requiring to be paid for, not only with medical benefit, but also with sickness benefit, under the Insurance Act, in the present state of public opinion. At the opening of the Health Exhibition, in 1884, Sir James Paget, the great surgeon, showed, from the figures of friendly societies, that the nation was annually losing by sickness twenty million weeks' work; he showed that the great infectious diseases accounted for only one-tenth part of this immense economic loss, the greater part of which he attributed to personal conduct, and notably intemperance.

Some precise figures have now been obtained by impartial actuarial inquiry. Thus a recent report of the Public Actuary of South Australia, quoted by Dr. Newsholme, shows that, among abstainers' societies, the number of days of sickness

THE FIGHT OF THE TOWNS AGAINST ALCOHOL

This famous poster, first issued by the city of Sheffield, has been adopted by many towns as giving a municipal lead to the fight against alcohol.

CITY OF SHEFFIELD

ABUSE OF ALCOHOL

The Committee on Physical Deterioration appointed by Parliament in 1903, after hearing many witnesses with regard to the abuse of alcohol, expressed themselves as follows:

"As the result of the evidence laid before them, the Committee are convinced that the abuse of Alcoholic Stimulants is a most potent and deadly agent of Physical Deterioration."

The Corporation of Sheffield cordially concur with the recommendation of this Committee that some effort should be made to bring home to the community the gravity of this state of affairs, and for that purpose the following facts with regard to alcohol are set forth.

1. For adults, alcohol, whether in the form of beer, wines, or spirits, is unnecessary; for children it is injurious.

2. Persons doing hard work do not require alcohol. The hardest marches of British Soldiers have been accomplished, and the greatest privations of Arctic explorers have been endured, without alcohol. An Army Doctor of great experience, who is not a total abstainer, sums up the situation by saying "experience has shown that under no circumstances of fatigue, hardship, extreme heat, extreme cold, or bad weather, is an issue of alcohol necessary on active service."

3. Alcohol is of no use to Athletes. The trainers of pugilists and of football teams prefer their men to take no alcohol while in training, and find that the athletic career of the teetotaler is a longer one than that of his fellows who are not teetotalers. If, as a concession, any alcohol is allowed by trainers, a glass of beer at dinner and a glass of beer at supper is the limit. The taking of even this quantity is admitted to be a hindrance to an athlete's being at his best. In the course of a debate in the Midlands on this subject, a champion athlete, who happened to be an officer of the local Licensed Victuallers' Association, had to admit that when he went into training he took no alcohol. A well-known north country athlete relates how his competitors used to complain that he had an unfair advantage over them because he was a teetotaler and they were only teetotal during training, and always had some leeway to make up at the beginning of their training.

The following are examples of well-known sportsmen who recommend total abstinence for athletes—

F. C. SELOUS—The Big-Game Hunter.
BURGESS and BEAUREPAIRE—Swimmers.
VICTOR TRUMPER—Australian Cricketer.
E. P. WESTON—American Long-Distance Walker.

4. It is a mistake to think that alcohol keeps out the cold. On the contrary it increases the chance of a chill by drawing more blood to the skin, and thus cooling the blood.

5. Persons who take alcoholic drinks should regard them merely as a luxury and should be extremely careful in their use, as it is quite possible for the habitual drinker of alcohol to ruin his health by its means without ever getting drunk. The practice of drinking between meals is especially bad, and the custom of "standing drinks round" is almost sure to lead to excess.

6. The habit of drinking to excess leads to the ruin of families, to the neglect of social duties, to disgust for work, to misery, theft, and crime; and the abuse of alcohol is one of the chief causes which fills our workhouses, prisons, and lunatic asylums.

The abuse of alcohol may cause Delirium Tremens, Insanity, Diseases of the Liver and Stomach, and many forms of ill-health; it also creates a tendency to Consumption or Tuberculosis. Diseases such as Typhoid Fever, Pneumonia, and Erysipelas are much more fatal, and wounds or injuries heal with much greater difficulty if the patient has been an excessive drinker.

7. The children of excessive drinkers are liable to be weakly at birth or to develop weakness of mind or body in later life.

In short Alcohol is a luxury and not a necessity, and its abuse is a most terrible danger to personal health, to family happiness, and to national prosperity.

ALBERT J. HOBSON, Lord Mayor.
R M. PRESCOTT, Town Clerk.
HAROLD SCURFIELD, Medical Officer of Health.

annually is, on the average, about eight, and among non-abstainers' societies about sixteen. In the former societies, each sick member was sick, on the average, for 6·4 weeks; among the latter the figure was 10·9. And many of the members of the non-abstainers' societies are, in fact, abstainers, so that even these figures understate the contrast. In Dr. Newsholme's words, "The net result approaches two to one in favour of the abstainer, who thus lives longer and more healthfully than his non-abstaining friends. And, finally, when he is sick, he makes a more speedy recovery."

Such is the clear evidence, and it is our duty to insist upon its conclusions before we leave the study of the laws of health. Those laws are not merely a matter for personal choice, affecting only the individual first concerned. By far the greater part of illness involves infection and risk to others, quite apart from the enormous economic burden of sickness to which the above authorities refer. A man, therefore, has a duty to others as well as to himself. The maintenance of health, and the avoidance of the conditions which induce disease, are a matter of public and social duty on the part of every member of the community.

The Danger of Small-Pox to Public Health Through Private Irresponsibility

But the growth of public responsibility is involving the growth of private irresponsibility. A remarkable instance, which may at any time have the most serious consequences, is the steady decline of vaccination in this country. For several years there has been no great epidemic of small-pox to frighten people. A modification of the law left the matter of vaccination to the free and ignorant choice of parents, and the number of those who avail themselves of the clause regarding conscientious objection steadily rises. The sense of personal responsibility for personal conduct, to others and to the community at large, has declined, or at any rate has not developed sufficiently. When the next great epidemic of small-pox, for which we are preparing the conditions, appears, it will be recognised that no community is safe which permits individuals to follow any course of conduct that they happen to prefer, in matters of health.

In an extremely popular print the doctrine was lately laid down that what a man does in private cannot possibly injure anyone else, and is therefore his own affair, with which the community has no right to interfere. Nothing more foolish was ever said. Whatever may be the rights of the community, it is certain that everything which a man does in private is liable to affect his subsequent conduct, and therefore other people. The book he chooses to read in private may have the most tremendous consequences for good or for evil upon any or many of his neighbours an hour later. The right of the community to interfere with personal liberty is a most difficult question, but it will never be solved by those who assume that it is possible for a man's private conduct to have no public consequences. No man liveth to himself; whatever he does or refrains from doing, other people are affected.

The Bad Citizenship of People who do not Care for their Health

Above all is this true in regard to matters of health. The man who privately commits suicide instantly may do harm to a few, but only to those who love him or are dependent upon him. The man who commits a slow suicide by personal conduct which, besides shortening his life, makes him a burden upon others, and a purveyor of disease in many cases, escapes our reprobation. But such men are among the worst enemies of society, and the total aggregate of the burden they place upon its shoulders, and of the illness and death they distribute, is an appalling one. In past times men could look at such things differently. An epidemic was a visitation of Providence; disease was an act of God; the mutual dependence of the individual units of a community was even less realised than it is today, and no one knew that, for instance, the most deadly of all diseases is an infection the incidence of which upon anyone involves danger for others.

The Laws of Health Applied to the Individual the only Real Safeguard

In the light of our modern knowledge, the sphere of personal responsibility for disease has enormously increased, though the tendency of legislation is to make us all assume the opposite, and to suppose that a nation can be made healthy by Act of Parliament. Parliament may provide the conditions for all, in which, if they choose, they may attain an average of health and of duration of life unknown in any preceding age of human history. But the only Act of Parliament which made a people healthy without their voluntary co-operation would be one which dictated their private conduct from morning till night, and from night till morning; and even that would have its difficulties, since we all differ, and what is hygienic conduct for one man, giving him

health and strength and happiness, might be destructive of all three in his neighbour. A healthy people can be made only by such legislative and social conditions as make it *possible* for all to follow the laws of health as they apply to themselves, and by the observance of those laws on the part of all.

Knowledge and opportunity are invaluable and indispensable ; everyone who thinks it worth while to teach hygiene, or to demand hygienic legislation, assumes so much. But the simple truth is that knowledge and opportunity are not all. It has been shown, by the simple process of counting, that there are no more open windows at any given moment in Harley Street than elsewhere. The factor of what people choose to do, with all their knowledge and opportunity, remains. For the great majority of people in this country, the opportunities for health, and their knowledge of its laws, are less than sufficient. But there are many people who have enough money, who can live in healthy surroundings, who can buy unadulterated food of any kind they like, and who have access to the best medical advice on all matters of health. Is it to be assumed that doctors find no cases of preventable disease, due to personal misconduct or "physiological sin," on the part of such people ?

The People with Plenty of Money who Choose Bad Health

On the contrary, there are many people whose opportunities for health of body and mind are *too* good, and who would enjoy more health of both if circumstances compelled them to work for their living, even in the unhygienic surroundings of an ordinary shop or office. There are plenty of doctors, well aware of the laws of health and of the properties of alcohol, who are drinking themselves to death, and plenty more who are killing themselves with worry and over-work due to the desire to cut a figure in the social world. As for those of the well-to-do who suffer from ill-health due to over-eating and indulgence in drugs and lack of exercise, their name is legion. They have knowledge or ready access to knowledge, and they have opportunity. No laws of any kind are needed for their protection ; no laws would protect them. Personal conduct is the *crux* of their case.

It is therefore not to be supposed that the establishment of right conditions of housing and ventilation, and inspected milk and other food, and free doctoring, and notification and isolation of infections, is going to accomplish for the masses of the people what good conditions cannot accomplish for the most fortunate. The maintenance of health is a two-fold matter, partly dependent upon public action, but partly also upon private action. Where public action fails, no apology is to be made for it ; but what shall we say where public action does its best, and the individual will not do his share ? As in everything else, there comes the point where people must save themselves. A man may have the earth ransacked for his food, without his stirring a finger ; he may have that food cooked so that it needs no chewing, inserted by a tube so that it needs no swallowing, treated with ferments so that it needs no digestion, but he must absorb it for himself, or he will surely starve to death. The united forces of all the rest of mankind cannot do everything for any one of us.

The Need for Private Conscience as Regards Health to Supplement Public Duty

The kind of personal conduct which conduces to health is therefore to be looked upon as part of every man's duty, about which he must develop a conscience, as about other things. Society having done its share, is entitled to ask him to do his. It provides the knowledge and the opportunity, and he must do the rest. Even-handed justice, as we conceive it, will not be found to reign. We are so differently endowed in matters of health that one man may do what he pleases, almost, as regards diet and work—may neglect his sleep, his skin, his duty of exercise—and he will be happy and prosper ; relatively, at any rate, to another man, less fortunate, who has to be careful about everything he swallows, never indulges, and yet is a victim to chronic dyspepsia. Similarly as regards the mind. Professor F. W. Mott has lately remarked that apparently nothing will drive some people mad—worry, drink, influenza, and so forth will pass over them and leave the mind still stable and sane. Other people, under the slightest action of such influences, are thrown off their mental balance at once.

More Health and Longer Life the Reward of Hygienic Virtue

No hygienic virtue can win equal health for all of us, or health at all for some of us ; but it may most positively be asserted that hygienic virtue wins the reward of more health and longer, or of less ill-health, for all who practise it. That is the reward which the hygienist may confidently offer to his reader, with all it means for the happiness and the usefulness of the individual and the community.

THE RETURN TO UNCONFINED SPACE OF THE EARTH-BOUND SPIRITS OF LIGHT AND POWER

OIL AS A SOURCE OF LIGHT AND POWER, AS SYMBOLISED IN MR. EDWIN ABBEY'S FRESCO ENTITLED "THE SPIRIT OF LIGHT," IN THE STATE CAPITOL, HARRISBURG, PENNSYLVANIA. From a photograph by Messrs. Curtis and Cameron

FUTURE SOURCES OF POWER

An Inquiry as to the Amount of the Energy of the Universe that Man May Exploit

MECHANICAL DEVICES AND MOTIVE FORCES

From a scientific point of view, neither the manual labourer nor the capitalist has in himself much to do with the actual creation of the real wealth of the modern world. For this wealth consists mainly of stores of fuel energy that have taken millions of years to accumulate. No man, or class of men, created it. It is beyond the power of man to create the real wealth of our industrial civilisation. All he can do is to find the treasure, and then work out some ingenious means of exploiting it. But all his ingenuity counts for nothing if there is no treasure of which he can make use. At the present time we are using up our chief sources of power so rapidly that our descendants may find themselves, in spite of all their scientific knowledge and industrial skill, in a condition of miserable poverty.

All that they are certain to inherit from us is a knowledge of the mechanical powers and similar things in electricity and chemistry. It is often said that knowledge is power, but in the absence of some large source of available natural energy a practical acquaintance with the mechanical powers will not be of much use. It is true that the development of the six mechanical powers—the lever, the pulley, the wheel and axle, the inclined plane, the wedge, and the screw—has been the master event of the modern era. Out of them has been evolved the marvellous machinery that has enabled us to exploit the immense stores of energy accumulated in coal mine, forest peat-bed, and oil field. But exploitation is not creation.

At first glance, no doubt, the mechanical powers seem to add enormously to the natural sum of energy. Take the simplest form of the lever—a straight iron bar. With this, Archimedes, the first man to study levers in a scientific way, said he could move the earth, if only the bar were of sufficient length. Certainly a bar of iron, or even of wood, enables a man to do work that would otherwise be quite beyond his ability. Suppose there is, for instance, a rock weighing five hundredweight that has to be removed from a path. An ordinary man cannot lift much more than a hundredweight, so without mechanical aid he cannot tackle the rock. But if he puts one end of a long iron rod under the boulder, and places fairly close to the end of the bar a log of wood to serve as a prop or fulcrum, then by pressing on the long free end of the bar he can easily move the heavy rock. A pressure of a hundredweight at the long free end lifts up the five hundredweight stone at the other end.

On a smaller scale, a common hammer, just a foot long, performs the same apparent miracle. By using an effort of twenty-five pounds at the handle of the hammer when driving in a nail, a weight of one hundred and fifty pounds can be delivered on the nail. The most generally useful of mechanical powers is the screw. By turning a screw-jack a single man can lift two tons. He can place a derailed locomotive-engine back on the lines. This appears an extraordinary enrichment of the muscular energy of a human being. But it is quite insignificant in comparison with the mechanical advantage obtained by means of an hydraulic press. Let us take one of these presses, consisting of two cylinders filled with water and connected by a pipe. In the large cylinder there works a piston eight inches in diameter, while the piston working with a pump action in the small cylinder is only half an inch in diameter. This small piston is operated by means of a handle five feet long that rests on a prop, or

fulcrum, an inch away from the attachment to the piston. Now, if a man weighing fifteen stone merely sits on the end of the handle of this machine, the pressure he communicates to the water, and thence to the large piston, is so magnified that it is sufficient to raise 1440 tons!

This increase of working energy by means of mechanical powers is really an illusion. Nothing whatever is actually gained. Take the first example we gave of the use of a lever, consisting of a straight bar of iron placed under a boulder weighing five hundredweight. The man applies a hundredweight at the farther end of the bar, and shifts the heavier obstacle. But what happens is this. The pressure of one hundredweight has to be exerted continuously until the free end of the bar has moved, say, five inches downwards; the other end of the bar under the stone will then move upward one inch, carrying the five hundredweight boulder with it. The use of the lever merely serves to translate the work of lowering one hundredweight to a depth of five inches into the work of raising five hundredweight to a height of one inch.

The Illusion of a Gain of Energy by Using Mechanical Powers

In scientific phrase, what is gained in force is lost in distance. The mechanical advantage is purchased by increasing the length of the effort. A man weighing fifteen stone may sit a very long time on the handle of an hydraulic press in order to lift 1440 tons of iron. By means of its mechanical powers the machine acts as a kind of bank of energy. By paying into a screw-jack small but continuous amounts of muscular power, which is done by turning the lever with a strenuous and muscular effort, the workman is able at last to draw a cheque for two tons of energy delivered at the spot where he requires to use it.

What the lever does for mechanical power, the transformer does for electric power. Exert a small force for a long distance at the long end of a lever, and you have at the other end a large force exerted through a short distance. Apply a small electric pressure with a large current at one side of a transformer, and you have a large pressure with a small current at the other side. In neither case is there any actual gain in power. This is clearly brought out when a lever is employed to deliver a small amount of power over a long distance. For in this case a large amount of power must be communicated to the lever over a short distance. The human forearm and hand form a lever of this kind. It translates a large muscular effort into a rapid but feebler amount of power.

Levers of this sort always work at a mechanical disadvantage, but what is lost in power is gained in speed and range of movement. For instance, the muscles of the upper arm must—leaving out the weight of the forearm—exert a six pound pull in order to raise a one pound mass in the hand.

The Compensation of Quickness for Loss of Power

But the quickness and the flexibility of the hand's action somewhat compensates for the loss in transmitted power. We thus see that when primitive man first used a lever formed of a fairly straight branch of a tree, he did not win any real increase of energy. He merely obtained a means of accumulating his muscular effort, so that he could deliver a blow with the force of perhaps a quarter of a ton. But to do this he had to swing his club over a long distance; and many a time when the cave bear was quick in attack, primitive man must have dimly recognised the disadvantage of gaining power at the expense of speed of movement.

The most serious disadvantage of the use of mechanical powers, and of the machines in which they are combined, is an actual loss of energy through the friction of the parts. A man must put more than two tons of energy into a screw-jack in order to lift an engine of that weight; for a great deal of his muscular effort is spent in overcoming friction. In many cases, the friction of machinery can be somewhat diminished by the use of lubricants. But these lubricants are forms of natural energy. So in using them man is drawing on the natural sources of power.

The Worth of a Man as an Engine of Force

Man himself is, of course, a form of natural power—a living machine that transforms food into energy. In systems of slave-holding and forced labour, the power of the human machine is of high mechanical importance. Most of the great works of the ancient world were accomplished by means of it; and it is still, under the finer system of hired manual labour, the most generally valuable and convenient instrument of work. A man exerts his greatest power by rowing, or by walking up a ladder or a treadmill. But for ordinary labour, the turning of a winch-handle is the more

ADAPTATIONS OF THE INCLINED PLANE

A SIMPLE PRINCIPLE IN APPLYING POWER SHOWN IN TWENTY DIFFERENT WAYS

convenient, though much less perfect method of applying human energy. On a winch-handle, a man can work for eight hours a day at the rate of 2200 to 3300 foot-pounds a minute.

For a little time he can work about eight times this rate. But if he does this he must afterwards have a considerable rest. Regarded as a prime mover, a man is a motor of quite small power, with an output for eight hours a day of about 4-50ths of one horse-power. He is about half as good as a donkey, which can work at the rate of 5000 foot-pounds a minute. An ox does about 16,000 foot-pounds a minute; and for an eight-hour-day, a horse will work at the rate of 22,000 to 33,000 foot-pounds a minute. That is to say, a horse is about ten times as powerful a machine as a man is. It does the work of ten slaves or labourers. In, however, driving machinery by means of a horse-gear, a horse does not work at its best. It is then often equal to a steam-engine of about ½ horse-power.

By far the greatest quantity of the work of the manufacturing world was performed by animal power before the invention of the steam-engine. Both horses and oxen had then become of great importance as living sources of motive-power. In agricultural industries, and in transport, they were the chief prime movers possessed by the leading nations of the world. And by confining them to a circular track, and making them move a long wooden shaft attached to a train of wheels, their muscular energy was converted into the driving force of various kinds of machinery. They were costly motors, by reason of the expense of feeding and lodging them, but they had the great advantage of working in a regular and constant manner The horse especially was so adaptable a motor that even the invention and development of the steam-engine did not make him useless. It is only since the internal combustion-engine grew more efficient that the most convenient form of animal power has become in danger of being generally superseded by a mechanical device.

At the present time, mechanical energy is cheaper than animal power, largely by reason of the fact that the civilised world has recently discovered accumulations of fuel of vast extent. Forests, coalfields, petroleum deposits, and peat-beds now constitute the principal sources of power on the earth. But, since the invention of the steam-engine and the oil-engine, they have been exploited so immensely and so extravagantly that they will not last very long. Even when the electrical methods of making use of the energies stored in coal are put into general practice in the coming Electric Age of civilisation, it is probable that in much less than a thousand years our country will be absolutely bankrupt of its present treasures of industrial power. That is to say, in less than the time that separates us from the Norman Conquest, our descendants will be reduced to a position of impotence. And so will all other nations that depend on the present sources of fuel for the heat energy they use for domestic and industrial purposes

PLOUGHING WITH TEAMS OF OXEN IN PORTO RICO—AN EARLY STAGE OF POWER

As modern progress is vitally related to the stores of natural energy that we are rapidly using up, there is some danger that the existing stage of civilisation, with its extraordinary abundance of cheaply manufactured articles and cheaply transported foods and goods, may only be a brilliant interlude between the dark ages of the past and the dark ages of the future. Our iron slaves will only enfranchise us from the hard labour of existence, and enable us to develop a lovelier and nobler way of life, provided that they are for ever fed with the food they require.

So it becomes important to examine all the sources of power, either within our reach, or likely to be brought within the reach of our descendants. There are five sources of energy on our earth. First, there is the energy leaving the sun, and reaching our world as radiant heat and light. Secondly, there is the heat energy stored in the earth, and available in the high temperature of its interior. Thirdly, there is the energy possessed by the earth in virtue of its daily rotation. And, combined with this form of energy, is the gravitational pull of the sun and earth and moon. In the fourth place, is the energy liberated when chemical combinations occur between the various elements or compound substances existing on the earth. And in the fifth place, there is the still obscure energy of magnetic and electro-magnetic forces, playing over and in our planet; and further, there is the electro-magnetic centres of force out of which the substance of everything is formed.

At present, we run all our machines on a small part of the first and fourth of these sources of energy. We use the heat and light of the sun as stored in plants and trees of coal mines, in forests and peat-beds and petroleum deposits. There is some dispute about the origin of petroleum; the more likely theory is that it is formed, like coal and peat, from the organic remains of plants. There is, however, just a possibility that it is a compound, elaborated by chemical action out of substances that naturally occur in the depths of the earth. However this may be, both coal and oil belong to the fourth or chemical source of energy, as well as to the first or solar source of power. For work is obtained from them by devising means of making them enter into chemical combination with the oxygen of the air. In other words, they are subjected to a process of combustion either in some form of furnace or in an explosion chamber, such as constitutes the main feature of an internal combustion engine.

MODERN POWER IN A PRIMITIVE INDUSTRY—PLOUGHING BY MACHINERY IN SOUTH CALIFORNIA

In addition to the radiant energy of the sun stored in coalfields and oilfields and peat-beds, we are also now beginning to use in a large way the water power that the sun creates from the steaming seas. The sea water evaporated by solar heat, and brought down on the land in rain and snow, provides us with that energy of rivers and waterfalls which is now being transformed into electric power in many parts of the world. At Niagara Falls, there are from three to four million units of horse-power available for work. This is about equal to the manual-

power of a good deal more than 100 million men of average strength working eight hours a day. In the last ten years, Switzerland has become the cheapest producer in the world of certain kinds of manufactured articles, by reason of the fact that the supply of water-power there is abundant and regular. Only a great climatic change can rob the Swiss of their natural sources of power, which have recently become available through the invention and development of electrical generators connected with modern types of water-wheels. It is not likely that the conditions of the Great Ice Age of Europe will recur for ten thousand years; so the Swiss nation is in no immediate danger of its main source of power turning into ice, and burying all the country.

The energy of solar heat is also indirectly available for mechanical work in the form of the mighty movements of air caused by changes of atmospheric pressure. In warm regions the air grows lighter and ascends, forming large spaces of diminished pressure towards which the winds from colder parts of the earth flow. This was the first source of mechanical energy of which man made use. He employed it by means of a skin stretched against the mast of a boat, and he afterwards wove a fabric from the fibres of a plant to serve as a sail. Windmills came into use in the twelfth century; and now, in a much improved form, they are likely to become an important device for obtaining mechanical power.

At present, the windmill is in a position similar to that which the water-wheel occupied before the invention of the modern electric generator. It is waiting for a cheap, convenient, and capacious instrument for storing the electrical power it generates when attached to a dynamo. When the irregular energy of the winds can be taken and stored cheaply in large quantities, so as to form a reservoir of power supplying a fixed and constant electric current to all kinds of machinery, man will possess in the winds as available and valuable store of industrial wealth as he has lately found in swift streams and waterfalls.

A MACHINE THAT CUTS A TUNNEL EIGHT FEET IN DIAMETER THROUGH THE HARDEST ROCK
By the use of compressed air the twenty-five drills within this machine chip away rock at the rate of three feet an hour, exerting a force of 50 tons against the rock, and replacing the work of thousands of men.

The most direct means of utilising the solar heat is a modern sun-plant. We have already described in POPULAR SCIENCE the plant devised by Mr. Frank Shuman, and installed at Meadi, a suburb of Cairo in Egypt, by the Eastern Sun-Power Company, of London. The plant has now been improved, with the result that its power has been increased more than three times. In its new form it consists of five reflectors, each 204 feet long, that concentrate the tropical heat of the sun into a zinc generator which is painted with a special black paint of great heat-absorbing qualities. At the upper edge of the generator is a steam collector 4 inches in diameter. The collector is connected at the upper end to the

"WHAT THE FIRST MAN SAW IN THE FIRE"

AN ARTIST'S CONCEPTION OF THE VISION OF THE UNKNOWN MAN WHO FIRST MADE A FIR!

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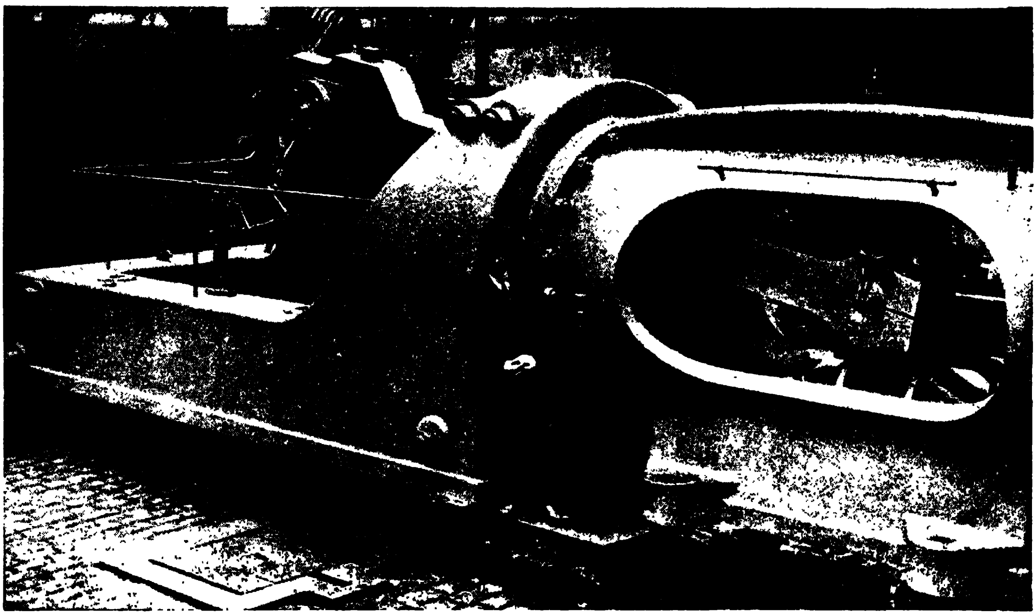
main steam pipe, and at the lower end is introduced the feed-water, which is converted into steam by the concentrated rays of the tropical sun.

The steam obtained in this manner is used in a low pressure engine, specially designed for the purpose, which gives exceedingly good results. There appears to be no doubt of the practical success of this curious and wonderful device, which is now working regularly and in good order. It is estimated that there are 20,000 square miles of land around the Mediterranean, the Nile valley, and the Red Sea, on which sun-power plants could profitably be fixed. This would supply an enormous amount of working energy, that would go far towards satisfying the demands of the entire world. It is quite possible that in the future the area suitable for working sun-power plants will be extended by irrigating the great deserts of the tropics, and thus supplying the feed-water necessary for the production of steam by the sun's rays. We are inclined to regard the sun-power plant as a very valuable addition to the future resources of the human race.

The second source of energy, consisting of the heat stored in the interior of the earth, has often attracted the attention of men of science. A few years ago, Camille Flammarion, the brilliant French astronomer, sketched a scheme for driving a huge shaft some good distance into the earth, and then working engines by means of the heat so obtained. There seems perhaps no unsurmountable engineering difficulties in the way of carrying out this astonishing proposal. The modern tunnel builder has driven shafts for a greater length than would be required to tap the heat of the earth, and he could probably find a way of reducing the temperature in which his men worked while mining for heat.

The trouble is that, if the shaft were made, it would not pay. Let us glance at the conditions of the problem. After the first hundred feet, the temperature of the interior of the earth increases one degree for each twenty yards of depth. So it would be necessary to sink a bore-hole 6000 yards in order to get a temperature of 380° Fahr. The bore-hole would have to be 260 yards in diameter to give a heat energy of 100 horse-power. Moreover, the shaft would have to be divided into a cold water feed-pipe and a steam main. The steam main would have to be carefully protected by non-conducting material from the colder feed-water pipe, or much of the steam would be chilled and condensed, and so lost in its ascent to the engine on the surface of the land.

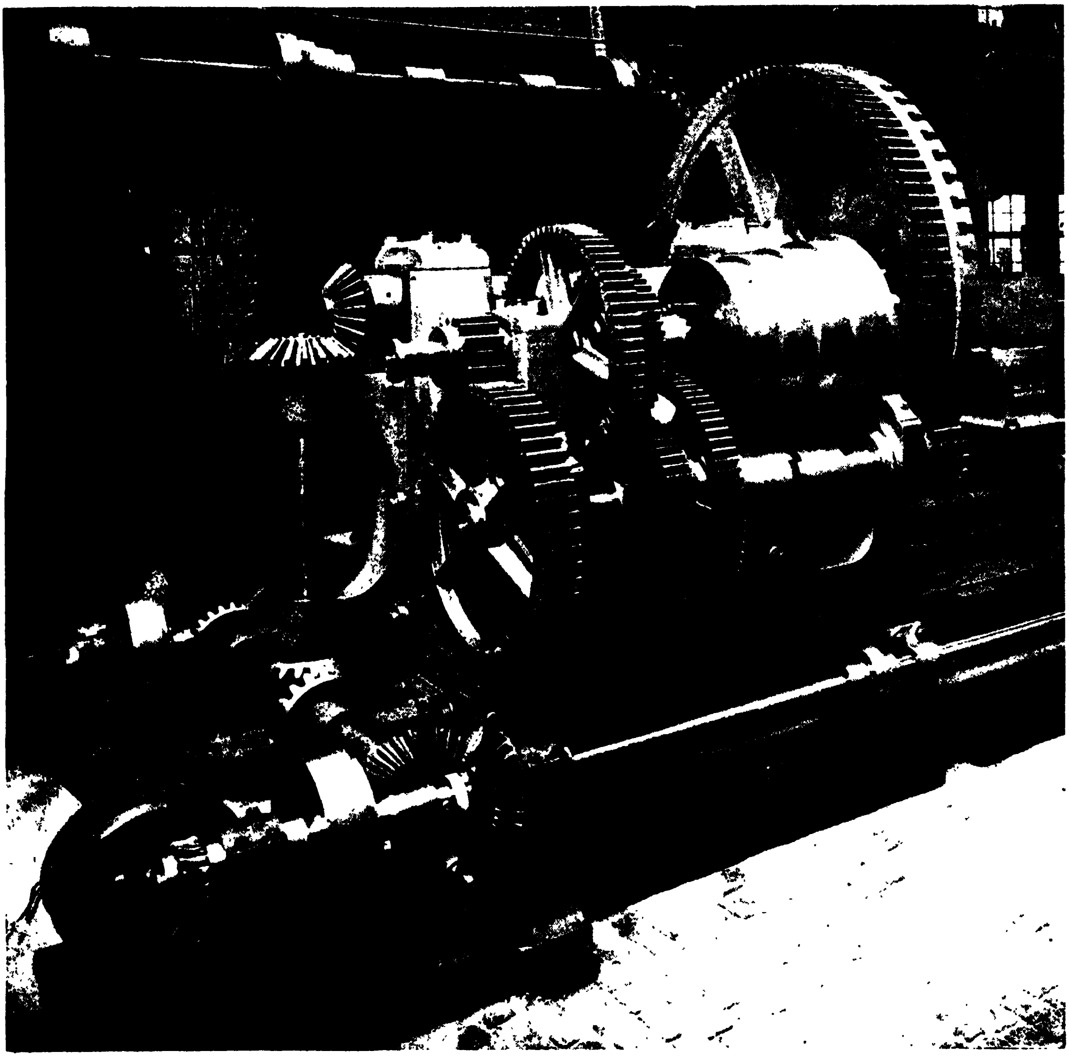


THE FRAME OF A VERY LARGE HORIZONTAL STEAM-ENGINE

Supposing all these difficulties were overcome, there would still remain an insuperable obstacle. The temperature of 380 degrees would be diminished by the first inflow of cold water, and as this cold water

ontinued to pour down, the temperature vould go on diminishing. In itself the lriving of a shaft of 160 yards in diameter .nd 6000 yards in length, in order to obtain nerely 100 horse-power, is an utterly mbusinesslike proposal. And the diminuion of the heat by the constant flow of cold vater is a serious danger that puts the vhole scheme quite beyond the range of oractical engineering.

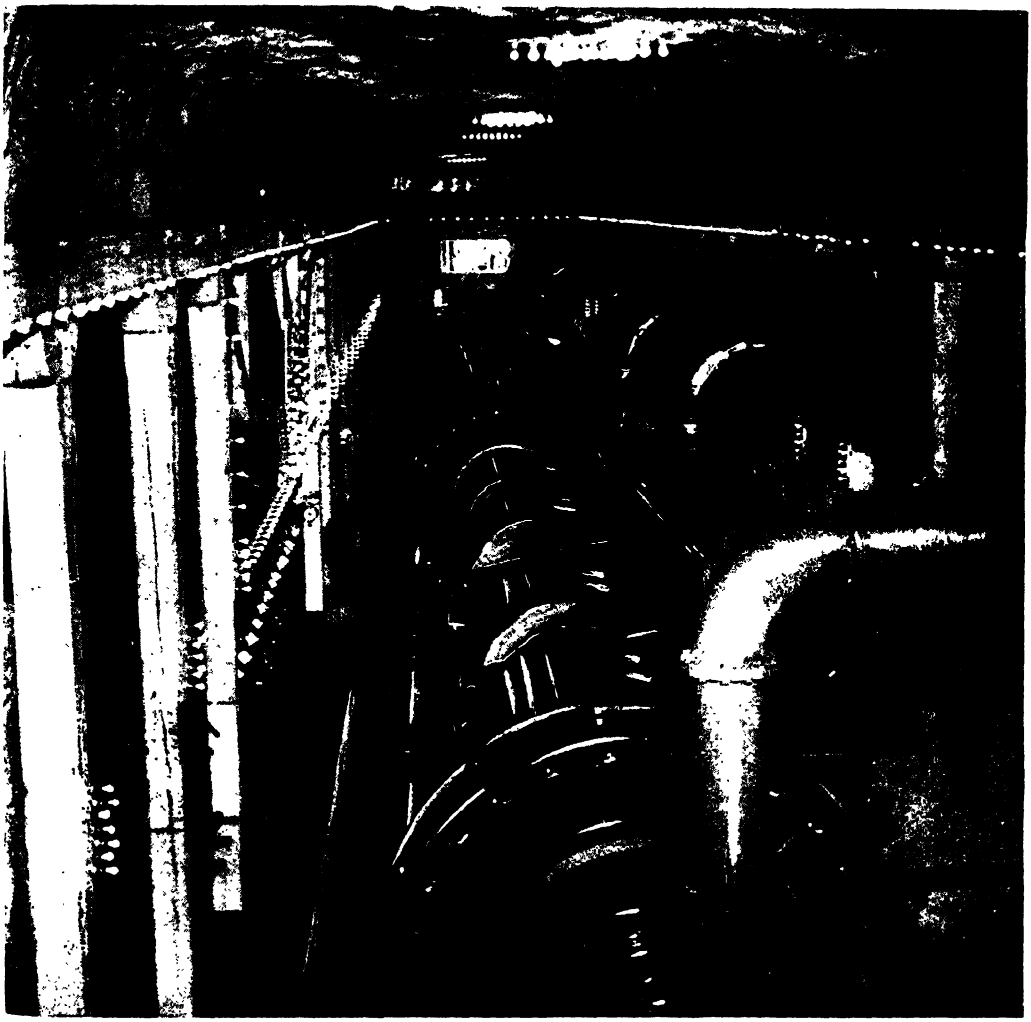
As a matter of fact, the human race ilready manages to utilise the heat of the nterior of our planet in the easiest and nost profitable way. By virtue of the :ontinual conduction of heat from the lepth to the surface of the earth this store of natural energy is admirably exploited in the form of food and timber. The heat of the earth co-operates with the heat of the sun in providing the herbage, vegetables, fruits, and green stuffs that support the animal life of our world. Even from the point of view of mechanical energy, it will always be cheaper to run engines on the alcohol obtained from potatoes, beetroots or cheap cereals, which are partly nourished by the heat spreading upwards from the hot heart of the earth, than to drive huge, long, expensive tunnels in a mad search for something we practically enjoy already.



VARIOUS TYPES OF GEARS EXHIBITED IN A MONSTER LATHE

More promising is the third source of energy due to the daily rotation of the earth,

and the gravitational pull of the sun and moon. The kinetic energy of the earth's rotation is such that mankind can never hope to make direct use of even a small amount of the tremendous energy with which the world spins from light to darkness. Neither is it possible for us ever to control the mysterious force of gravitation. water turbine has greatly increased the amount of motive force obtainable by empounding the flow of the seas. Of course, it will not pay to dig out immense tidal ponds by the shore. But there are many natural basins that need only to be closed in by a sea-wall, in order to be converted into important reservoirs of power.



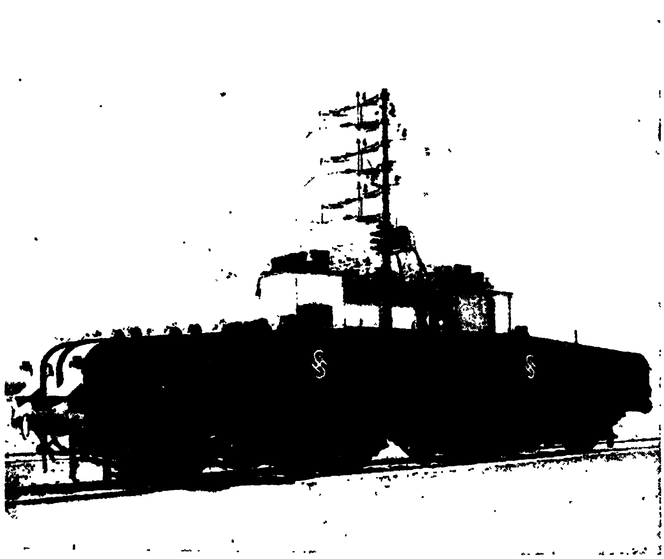
INTERIOR OF THE SNOQUALINE HYDRO-ELECTRIC POWER STATION, HEWN OUT OF SOLID ROCK

On the other hand, the tides that sweep over our seas are the result of the earth's rotation, combined with the gravitational effect of sun and earth and moon. For hundreds of years a little of the energy of the tides has been exploited by man, by means of tidal ponds and old-fashioned water-mills. The invention of the modern

For instance, some French engineers have recently worked out the expense of empounding the tides at Honfleur, by the mouth of the Seine. The prime cost comes to £11 16s. for each unit of horse-power, which compares favourably with the cost of obtaining power from coal at present prices. We have already given details of a

great undertaking for obtaining electric power from the sea tides off the coast of Schleswick-Holstein, and a smaller experimental effort is now being made at another point on the northern coast of Germany. There are, however, few places where the tides would give more than six feet mean working head. This means that, if the storage ponds were six feet deep, each square mile of reservoir would empound water of about 5000 horse-power for a five-hour run.

Hydraulic works on this scale would need a very large investment of capital in proportion to the amount of power obtained. Only where the configuration of the coast, or the presence of long island lines, enables an engineer to dispense with the most important sea wall, is the building of a tidal reservoir at present an economical means of running an electric generating plant. Yet there are some bays and estuaries where the tides give much more than a 6 feet head of working power. In the Bay of Fundy, for example, the high tide is 40 feet in height; and many million h.-p. hours daily run to waste there. The Bay of Fundy runs up into many narrow waterways and indentations where it might be possible to make arrangements for using the enormous power of its unparalleled tides. Through the narrow gap between two of its headlands the working power of 7500 million men, labouring 8 hours a day, flows away unused. It could be captured by building a high sea wall, 3 miles in length, between them. This is an engineering feat more tremendous than anything yet attempted by man. The money required for making the dam would be immense; it would tax the resources of Canada. But the return in working energy would be commensurate with the extraordinary out-



A MOTOR LOCOMOTIVE THAT TRAVELS OVER A HUNDRED MILES AN HOUR

This motor, built by Dr. Reichel in the beginning of the twentieth century, made trial speed trips on the Berlin-Zossen Railway, achieving the very high speed of over a hundred and twenty miles an hour. The motive power was secured from three wires giving an alternating current of 12,000 volts.

lay of money. It would convert the ba into a source of power a hundred tim superior to the Niagara Falls at their fulle period. We have not studied the engi eering difficulties of the scheme. The co of the dam would largely depend on tl problem of finding a firm foundation f the masonry amid the sand. The findi of rock or solid ground at a depth of a fe yards between the headlands would mak the scheme a gigantic, unparalleled, an yet practical piece of engineering.

In addition to the construction of tid reservoirs, there is another method making use of the energy of the tides. I has been carried out at times on a ver small scale by means of floating structure that rise an fall at floo and ebb, an transmit thei motion t some machin on the shor Allied to the in principle ar the wave-powe motors, consist ing of larg buoys moore off the coas and rockin amid the billows and communica ting, by mean of a wire cabl their rockin motion to machine on th neighbourin land. We a much afrai however, tha neither of thes floating sea-power plants will ever yield i a large way an amount of motive pow sufficient to return an ordinary amour of income on the capital expended in the construction, upkeep, and care.

We come now to the fourth great sour of natural energy—that obtained fro chemical combinations of the matter of ou earth. Were it not for the cost of suitabl material, the energy of chemical combina tions could be used in obtaining electric power that would be directly available fo useful work. We already have in th electric battery an example of a motiv force derived from chemical combinatio that is put to varied use. Since Alexan

Volta showed that electricity could be generated simply by bringing discs of copper and iron or copper and zinc together, new ideas of the production of power have stirred the imagination of men of science. The electro-chemical method of exploiting some of the main sources of power presents many and great advantages over the heat methods that are still in general use.

In heat methods, we change chemical energy into heat, and then change heat energy into mechanical power, and often go on to change mechanical power into electrical power. This is a roundabout and enormously wasteful way of getting work out of, say, coal. If it were possible to use the carbon of coke as the positive substance of an electro-motive cell, so that the gradual consumption of the carbon produced an electric current, a much greater proportion of the natural store of energy in coal could be directly turned into actual work. Many attempts have been made to reduce this idea to practice, and in some cases a small measure of success has been obtained.

Unfortunately, though carbon in the form of coke is a good conductor of electricity, it is electro-negative to all but a few elements. So if coke is used as the positive element of a battery, the choice of a suitable negative element is very limited. In spite of this, Mr. C. J. Reed and M. Jacques have each worked out a method of using coke in an electric battery. The construction, however, is costly and cumbrous, and the electric current obtained is of low voltage. It would, perhaps, be going too far to say that man will never be able to use his present sources of fuel to advantage in an electric battery, instead of in a furnace or gas-producer. But it is highly improbable that the main problem of our industrial civilisation will be solved along the lines that Reed and Jacques have pursued.

A NEW PHASE IN ELECTRIC TRACTION—THE TRAM ON RAILS PASSED BY THE TRACKLESS CAR

In the meantime, the chemist and the electrician have before them such vast tracts of unexplored and mysterious knowledge, that it is not unlikely that their future achievements will place new and tremendous sources of power within the reach of the engineer and the mechanic. For our part, we are sometimes inclined to think that grand revolution in the methods of exploiting the chemical energy of matter will be accomplished in an unexpected

direction. We look to the men of science engaged in the study of the chemistry of living bodies to throw a new and larger light upon the sources of power.

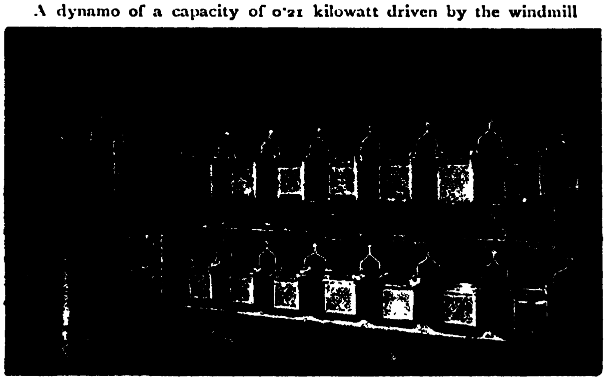
Consider, for instance, the work done by the tissues of our lungs every time we take in air. Air is a mixture of oxygen and nitrogen, but our bodies only need the oxygen in order to oxidise and get rid of the waste products in our blood. But oxygen and nitrogen tend forcibly to mix with each other; and to overcome their force of diffusion considerable energy is needed. To part the oxygen and nitrogen in a cubic foot of air of ordinary temperature requires an effort such as would lift a weight of 21 lb. one foot from the ground. But the lungs accomplish this work by rapid and easy means that are at present unknown. It would be a great gain in our industrial power if this function of the lungs could be imitated simply and cheaply. For the oxygen so obtained would, for many purposes, double the value of our present fuel supply. Cheap oxygen would greatly increase the amount of light derivable from gas and oil. In bleaching and in scores of other processes, oxygen is so valuable that, notwithstanding its present cost, the demand for it steadily increases. At a low price it would be available for a thousand new services. So the chemist who solves the problem of our lung power will do much to add to the industrial sources of mankind.

Besides separating oxygen from the air, our vital organs are every moment performing chemical tasks of equally general importance. The liver, for instance, is a sugar-maker with an amazingly economical method of manufacture, which no beet or cane factories can at present hope to imitate. Probably the secret of the extraordinary chemical power of living cells will ultimately be discovered by the study of what is known as catalytic action.

This we have already discussed at some length in POPULAR SCIENCE, so we will give only one illustration of it. A pinch of very fine platinum powder will suddenly turn sulphur dioxide into sulphuric acid; it will also rapidly split hydroperoxide into oxygen and water; and if a mixture of oxygen and hydrogen is brought into contact with the powder, an explosion immediately takes place. The extraordinary thing is that in all cases the tiny quantity of platinum powder is not diminished by the effect it produces in large masses of other substances. It is, so to speak, a practical source of perpetual motion, for it continues to act on mixture after mixture. A catalyser might, in a way, be compared to

A twelve-foot windmill on a farm in Wisconsin

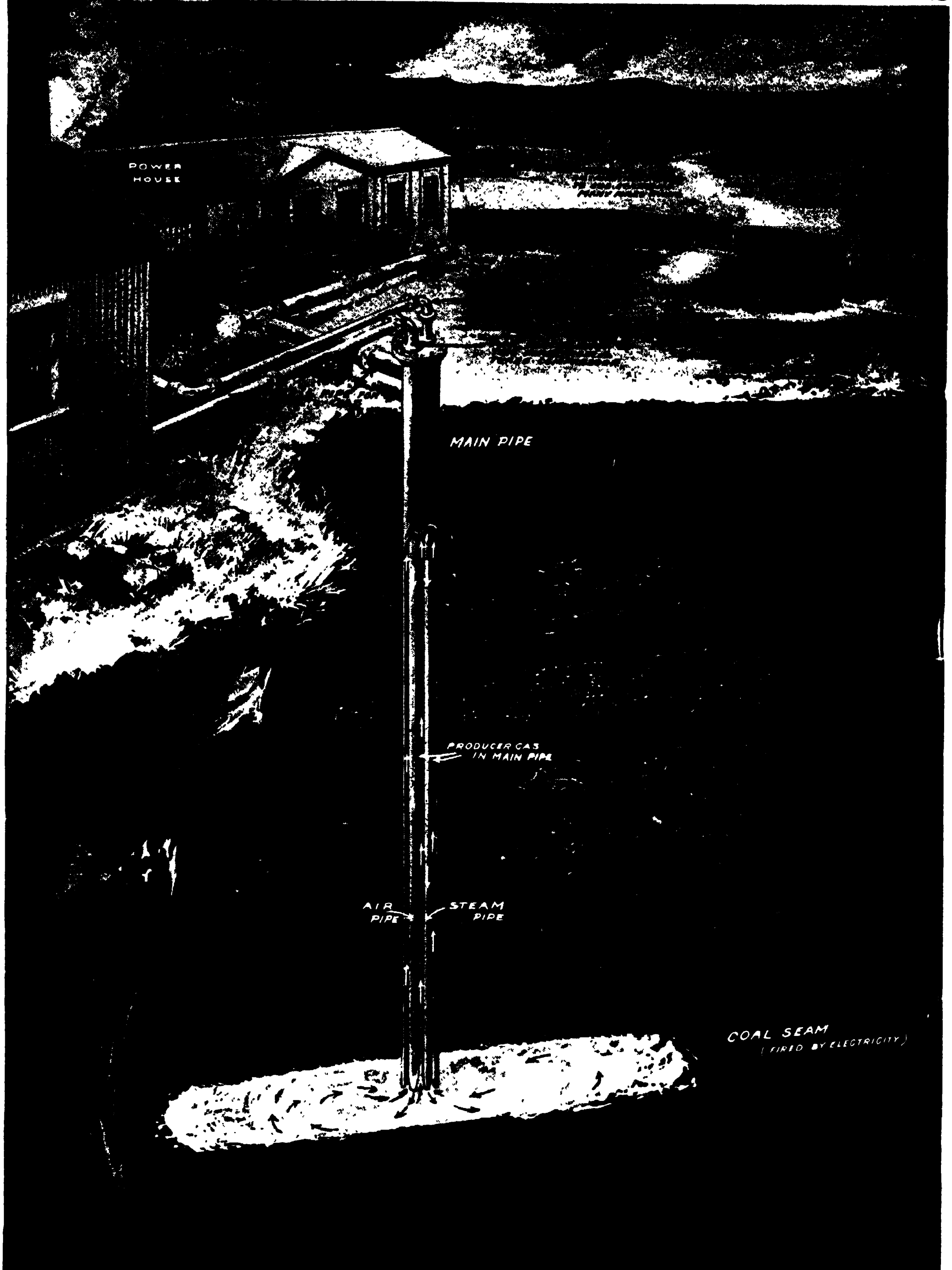
A dynamo of a capacity of 0·21 kilowatt driven by the windmill



A storage battery which accumulates the energy given by the dynamo when running, and gives 48 volts for lighting 24 Tungsten lamps.

ELECTRIC LIGHTING BY WIND-POWER

A DREAM OF TAPPING INTERNAL FIRES



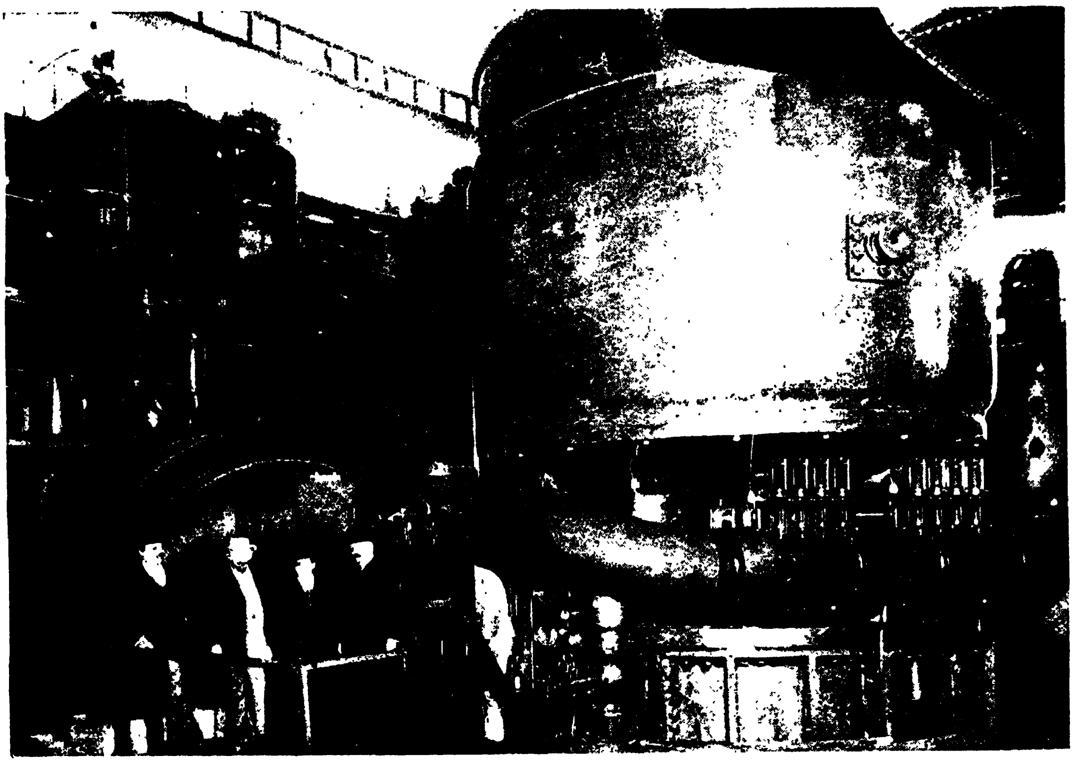
Sir William Ramsay has suggested that the firing of coal-beds *in situ* might provide cheaper gas and power than if the coal were burnt at the surface. The above diagram illustrates the suggestion.

an extraordinary kind of chemical, that produces a large roaring fire out of the oxygen of the surrounding air, and yet never burns away itself or wants replenishing. We need hardly say that such a chemical is not at present known to science. But quite as wonderful work is performed by various kinds of catalysing substances found in living bodies or made in chemical laboratories. It is on the study of catalytic reactions that we base our hope of a tremendous extension of human control over the chief natural sources of power.

Some men of science have already begun to dream of a catalyser that will enable mankind to exploit the ultimate and universal energy of the universe. We know, from the experiments of Professor Sir Joseph J. Thomson, that every atom of matter consists of a combination of positive and negative charges of electrical energy. We know also, from the experiments of Professor Rutherford, Professor Soddy, Sir William Ramsay and other men of science, that some heavy elements split into lighter elements, producing power as they do so. At present this transformation of the structure of certain forms of matter goes on in a natural way, and sometimes at a very slow pace. But if man could discover a catalyser that would bring about a fairly rapid change in the structure of common forms of matter, these forms of matter would then become vast and abundant stores of available power.

There is also another source of electromagnetic power in the magnetism of the earth, and an ingenious German has attempted to make use of this curious source of energy by fixing positive and negative collecting wires in a well made for a more directly useful purpose. He obtained a feeble but constant current of electricity; but we fear that his very original and scientifically interesting experiment is not likely to develop into anything of practical importance in industry.

Looking at the immediate future, we are of the opinion that alcohol cheaply obtained from potatoes is likely to become a source of power of general value for driving internal combustion engines. Petrol is becoming too expensive. Benzol a product of coal tar, must always be

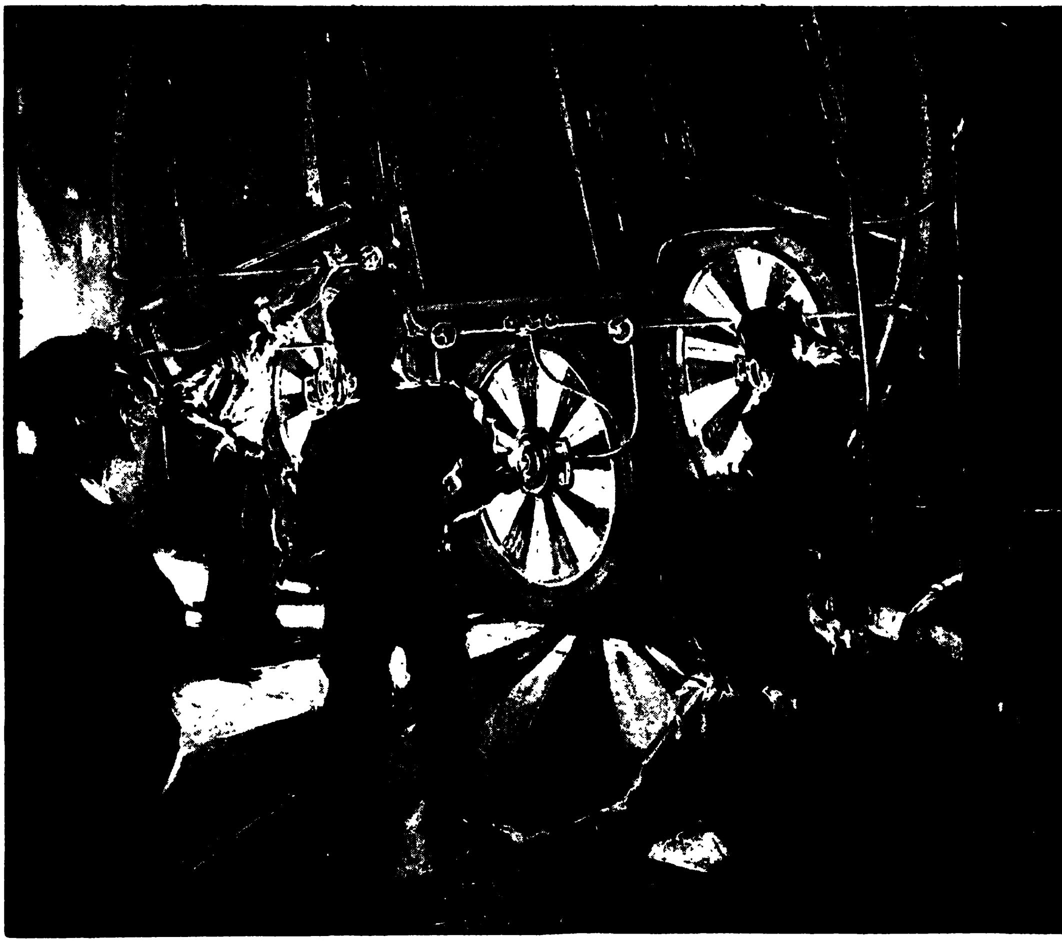


A 30,000 HORSE-POWER GENERATOR IN NEW YORK, SUPPLYING ELECTRIC CURRENT SUFFICIENT FOR THE NEEDS OF A CITY OF 250,000 PEOPLE

produced in too limited a quantity, and as soon as it is used to any considerable extent it will become costlier than crude oil. The same thing will happen in regard to coal tar, as soon as Dr. Deisel perfects his device for burning tar in his admirable engine. Industrial alcohol, on the other hand, forms a practically inexhaustible source of power.

It can be distilled from sawdust and cheap cereals as well as from potatoes and beetroots. One inventor, indeed, recently claimed that he could produce it at the cost of twopence a gallon. It has already been sold in Germany at 7½d. a gallon. It has a sweeter and smoother explosion than petrol has; and though it is somewhat naturally less powerful, this defect is balanced by the fact that it stands a higher compressure. For small high-speed engines, it is an excellent source of power; and we are confident that it is destined soon to be developed into the motive force of a large number of small machines and motor vehicles.

On farms, alcohol power will take the place of steam power, and gradually displace the horse; for it can be made on the spot, no coal or water is required, and no firemen needed. The alcohol motor is free from danger from fire, and economical in maintenance. Unless some new sources of fuel are discovered, alcohol will grow in importance as our coal-mines and oil-fields tend to exhaustion. It will not lose its value until electric power is generally obtained from a direct natural source of energy, and in much more abundance than is now the case. And even then, a cheap, light, and capacious means of storing electric power will be needed before the alcohol motor is antiquated and cast aside.



OIL INSTEAD OF COAL AS FUEL IN THE STOKEHOLD OF A CARGO STEAMER

The oil is forced into the furnace in the shape of a conical spray through a pipe, and bursts into flame about six inches from th nozzle. Only one or two men are needed for feeding the furnaces.

THE GREATEST TEST IN PACE AND DISTANCE

THE TWENTY-FOUR HOURS' RECORD RIDE BY MR. EDGE AT BROOKLANDS, WHEN IN A SIXTY HORSE-POWER CAR HE TRAVELLED 1581 MILES 1310 YARDS AT SIXTY-FIVE MILES AN HOUR

MAKING A MOTOR-CAR

The Wonders of the Machine that Enables a Man to Live Next Door to Everywhere

THE SECRETS OF BRITISH SUCCESS

THE chief difference between a motor-car and the magic carpet is that the motor-car has an actual, material existence. Otherwise they are twin wonders, the carpet in the realms of fancy, the car in our simple workaday world. The flights of the carpet are taken as read; the journeys of the car are timed and measured with care, and scarcely suffer by comparison. Given a roadway across the Channel, a motor-car could travel from the capital of Great Britain to the capital of Russia, a distance of 1700 miles, in some thirty hours. Such a calculation presupposes a road clear and practicable, and no speed limits. It is based on a specific performance—that of a Napier car which, in the summer of 1907, was driven by Mr. S. F. Edge a distance of 1581 miles in twenty-four hours—sixty-five miles an hour for a day and a night. It was a track performance, of course, but achieved over a pathway which became in parts so badly cut up as to approximate to desert conditions.

Not many people wish to drive at such a pace for so long a period, nor could if they would. But the feat is one which must always be remembered when the endurance of cars and men is considered, for there has been nothing like that ride of a night and a day in the history of the world. Think of the pace at which Constantine travelled across Europe when his Constantinople was still little Byzantium; of Napoleon's leaden-footed scurry back from Moscow; then compare the bird-like career of this iron man in his car of steel, covering in each *hour* of his ride as many miles as the two conquerors compassed between them in a *day*. Neither Constantine nor Napoleon, each with the wealth and industry of a continent at his command, could have anticipated this Englishman's feat. They had not the roads, they had not the machinery, they had not the faintest glimmering of the theory behind it all. It has taken longer to build a motor-car than it took to build Constantinople, or to establish or disestablish the First French Empire.

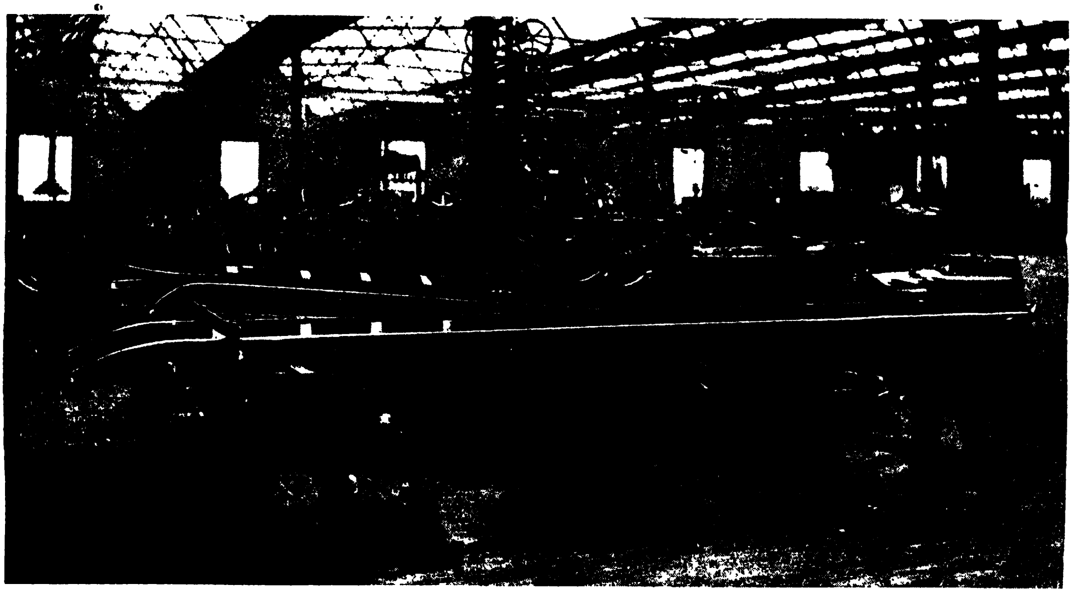
Not even the proudest owner of the newest car would pretend that his vehicle is nearly perfect. Automobile engineering is yet young. But, so far as it has gone, the thing seems a miracle of invention. The car stands before your door, with only a scarcely audible hum from the engine, like the purr of a contented kitten, to indicate that it contains any mechanism whatever. You take your seat at the wheel, slide a lever into place, take off the brake, touch a pedal with the toe, start away, make two, or it may be three, more changes of the gear-lever, and when you stop you may have covered from 400 to 500 miles. The car can do the journey if you have the staying-power to keep at the wheel.

To the man who knows the method the whole process is absurdly simple. The modern car is practically "fool-proof." All that the driver has to do is to give an eye to the rate at which the engine is fed with oil, to the petrol allowance and air-supply, and the car does the rest. The car is the embodiment of obedience. It crawls through traffic at five miles an hour, without noise, without smoke; it speeds along the open road at thirty, forty, fifty miles an hour. And the change in speed is effected simply by a touch of the foot, which increases the supply of petrol flowing to the carburettor. Given good nerve, clear sight, and the sense of pace and distance, anyone can drive a motor-car without the slightest difficulty. He need not have any special knowledge of mechanics—the majority of men in cars have none. It is because they have to

cater in the main for the latter type of owner that manufacturers have found it necessary to reduce their cars to models of simplicity. Simplicity is, after all, however, a relative term. This automatic machine, beautiful in outline, fast, silent, powerful, flexible, and easy of control, which the dullest of us drives without a qualm, is, after all, as complicated as a living organism.

Simplicity is effected not by crude or primitive processes, but by infinite refinements and niceties of invention and construction. A thousand arts have gone to its building. Before you set to work to build your car you must gather materials from the ends of the earth. Timber from far-scattered forests, iron from the North and West, petrol from the oil-fields of East and West, lubricants from the denizens of the ocean and from the nuts of tropical lands, lac from the insects parasitic upon the trees of the Far East to give you varnish for the body-work—all these go to make the car that whisks you to the station, or carries you luxuriously from Land's End to John o' Groat's.

When the materials are all collected, you must tap the brains of a century of inventors before you can metamorphose and weld them together. After the raw produce has been won, a score of industries must be invoked for the conversion of those materials. You must have the aid of electrician, of mechanic, of skilled draughtsman, of ironfounder, steel merchant, of chemist and metallurgist, to give you exactly the right degree of toughness, hardness, and resistance of steel. The nicest judgment must be exercised in meeting stresses and strains of all sorts, of twists here, thrusts there, of shocks in a third position. At every point where movement occurs the engineer is at war with friction. To effect these results he has to cram metals of the greatest possible strength into the smallest possible space, to secure a maximum of friction, and shock-resisting qualities with a mininum of weight. To effect this result the most complicated machinery and most highly trained mechanics must be employed, working from beginning to end to a scale of exactitude challenging comparison with the care of the watchmaker.

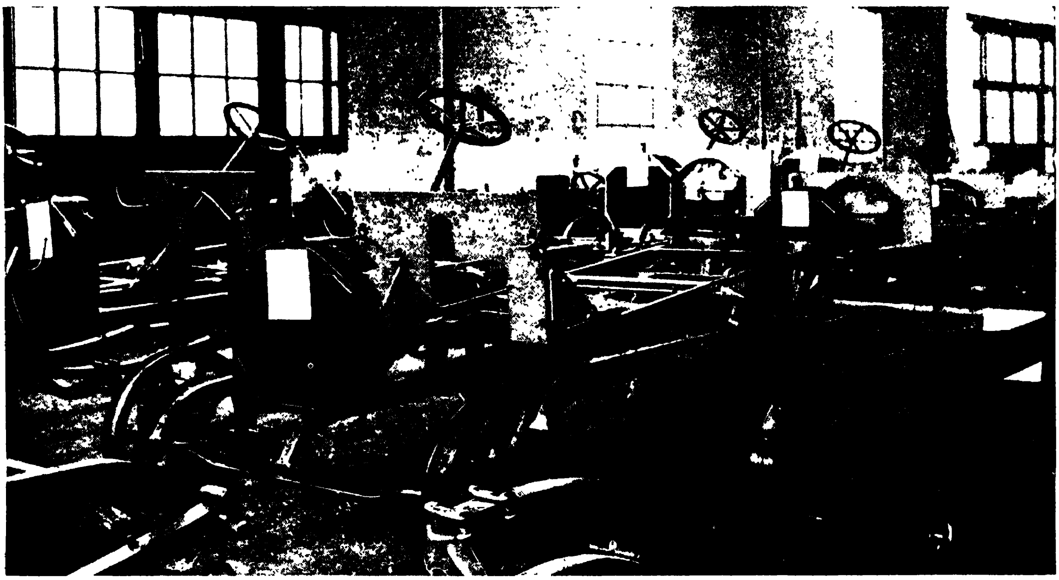


THE FIRST STAGE IN BUILDING A MOTOR CHASSIS—ASSEMBLING THE STEEL FRAMEWORK

It is because so many men and so many machines have worked so long and laboriously at the making of a car that the vehicle, when finally handed over to the purchaser, is a model of simplicity, and often endures without a breakdown the grossest mishandling. Take a fifteen horse-power Napier car, which is qualified to carry a man round the world and home again. Here is a very simple-looking but highly efficient car which any who will may drive. With all its simplicity in its ultimate stage, that car, without the body, contains no fewer than 3500 separate parts and pieces, yet all are so beautifully

combined that the whole work as simply as a clock. Such a car, which is ready, at the turn of a handle, to carry one to the uttermost ends of the earth, is the outcome of supreme co-ordination of infinitely complicated processes and inventions and of craftsmen skilled in many mechanical arts.

It is interesting to know what the building of such a car means in the matter of time. Of course, it would be impossible to build one car alone. Scores of cars are growing into being simultaneously. But, supposing that it were possible to take one car alone, it is computed that, from the first cutting of the steel to the final reassembling of parts following the taking down for inspection after trial, seven months would elapse. And the making of such a car would involve the additional complexity of method in the workshop. But for the imbecility of legal restrictions which for nearly a century retarded the industry, we should, in all likelihood, be far in advance even of the exalted position which British automobile engineering now commands in the markets of the world. The fact is that the idea of the horseless vehicle has danced through the brain of the inventive from days almost before history. There has always been someone anxious to travel a long way in a short time without the expenditure of energy better reserved for other ends. The story of the curious contrivances of these pioneers forms a long chapter in the history of mechanical locomotion, and may be consulted in works upon the subject. It suffices to recall the


THE WHEELS, RADIATOR, AND STEERING-GEAR FIXED TO THE FRAMEWORK

service of 250 men and 200 machines. That is the price the manufacturer pays for simplicity with efficiency. The process is different with certain American cars, where parts are slung together rough from the lathe, and frames are stamped out whole, like German tin toys. British manufacturers, in whatever they undertake, always make the best article of its kind in the world; and as British motor-cars are admittedly the best in the world today, we must note the lines on which their makers proceed.

The tendency in car-design is all in the direction of simplicity and more simplicity; but as easy reading involves hard writing, so simplicity to the driver will mean

fact that pioneers by whom the steam locomotive was evolved were the pioneers also of the motor-car. The idea of the steam-driven road vehicle was abroad in the eighteenth century. The names of Trevethick and Murdock, and the story of what they achieved, need no recapitulation, nor is it necessary to recall in detail the long battle for the right of the steam-driven vehicle to run upon the roads. When the scheme was in its cradle there were few roads upon which such carriages could run. When roads grew out of bogs and morasses, sufficient monstrous tolls were imposed to strangle the new industry.

It is a very striking fact that between 1832 and 1838 practically a dozen companies

were in existence for the sole purpose of running steam-coaches on the road. The mere names give an indication of the scope of the undertakings. There were, among others, the London and Birmingham Steam Carriage Company, Heaton's, the London, Holyhead, and Liverpool; the Steam Carriage Company of Scotland, the Hibernian Steam Coach Company, and the Steam Carriage and Waggon Company, to say nothing of numerous substantial firms engaged in building the vehicles. Incredible opposition had to be faced, from the rude, machinery-smashing rough of the villages, from the railways, and from multitudinous private interests. The owners of tolls, however, were the most formidable; they killed the steam-coach. A Parliamentary return of 1840 showed that on the Liverpool and Prescot road, whereas a loaded stage-coach would pay less than 4s., a steam-coach would be charged 48s. Rates for other routes were marked by the same iniquitous disparity. It was not until 1865 that an Act was passed unifying tolls, but this Act strangled the infant it affected to nurture. It imposed restrictions as to the character and speed of vehicles, which finally crushed the attempt to dispense with horses upon the roads. Thereafter the man who built and ran a steam-carriage did so at his peril, and in defiance of the law. It was not until 1896 that the statute books were cleared of the preposterous restrictions that kept down speed to four miles an hour, and insisted that a man with a red flag should precede the self-propelled vehicle.


THE ENGINE-CASING BEING BORED

Meanwhile the field had been left to the foreign inventor, who was subject to no such limitations. And here it is to be said that, had there been no statutory prohibition in the matter, we should still have been far from the motor-car that we know today. The pneumatic tyre had to be invented, and an entirely new form of engine discovered, before the car of today could be designed. The old steam-car, while it must have attained a high pitch of utility had its use been continued, could never have rivalled the modern machine. To obtain motive-power, coal had to be burnt and water converted into steam. The mere necessity to carry fuel and water in sufficient bulk for the purpose was in itself fatal. We had to find a new power-producer and a new engine to convert it into energy.

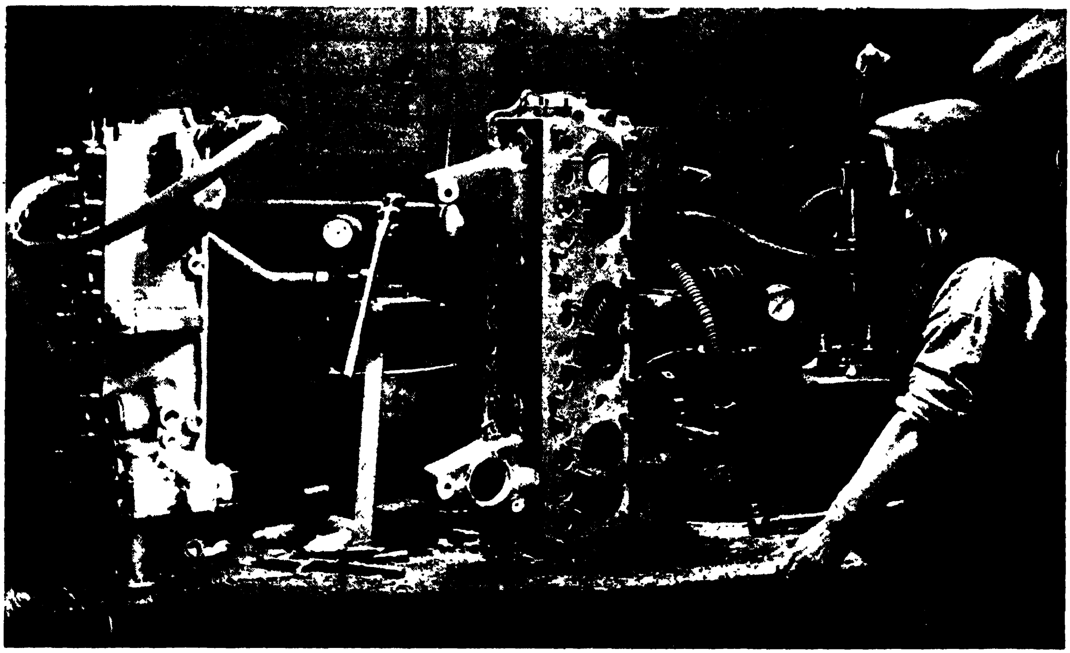
As everyone with the least knowledge of the subject is aware, the first inventor of the internal-combustion engine was Gottlieb Daimler, a native of Canstatt, Würtemburg, who, having had experience of the gas-engine, adapted the principle to the purposes of locomotion, using petroleum spirit as his fuel. His engine consisted of a single cylinder, into which an admixture of air and vapour from the volatile spirit was admitted and exploded, causing a piston to descend and turn a crank shaft, power being transmitted to the road-wheels by means of belts. It was a bicycle to which the first little engine was fitted, but that bicycle was the parent of every petrol-car in existence today. The principle was an entire departure from the old. There was no boiler, no coal or coke. The energy was derived from explosions of an inflammable mixture ignited actually within the engine itself.

Daimler's next advance was to an engine with two cylinders; and with this model, with a constant succession of modifications,

manufacture was first begun by Panhard and Levassor, and next by Peugeot Frères. At the same time, Benz was working independently at an internal-combustion engine similar in principle to that of Daimler ; and later there came the new steam-cars, in which, instead of a boiler carrying water and steam, the water was pumped through very small pipes which were kept red hot, and so instantly converted the liquid into steam. The success of certain steam-cars of this type, and particularly of the motor-'buses, suggests that we shall yet hear more of vehicles of this kind. Here, however, we are concerned with the petrol-car.

It is time now to consider more in detail the method by which the "wheels go round." The principle of the first Daimler internal-combustion engine still holds ; the newest and finest petrol-engine in the world has developed from that primitive contrivance. Today we have any number of cylinders, from one up to six, but a glance at the sequence of operations occurring in one cylinder reveals the story of the whole. The engine, as we have seen, derives its power from a mixture of air and volatised petroleum spirit. Petrol exposed to the air will vaporise. In the carburettor of a motor-car it is caused rapidly to vaporise by being broken up into very fine particles by means of a jet or jets. In the mixing-chamber to which it passes it is combined with air, so that the air becomes part of the actual charge by which the car is driven. The mixture is admitted into the cylinder by a valve in the cylinder head, and is drawn there by the action of the piston. This piston slides freely up and down inside the cylinder, but above the piston head the chamber is practically air-tight once the valves are closed, this being secured by an ingenious arrangement of rings let into and encircling the outer circumference of the piston.

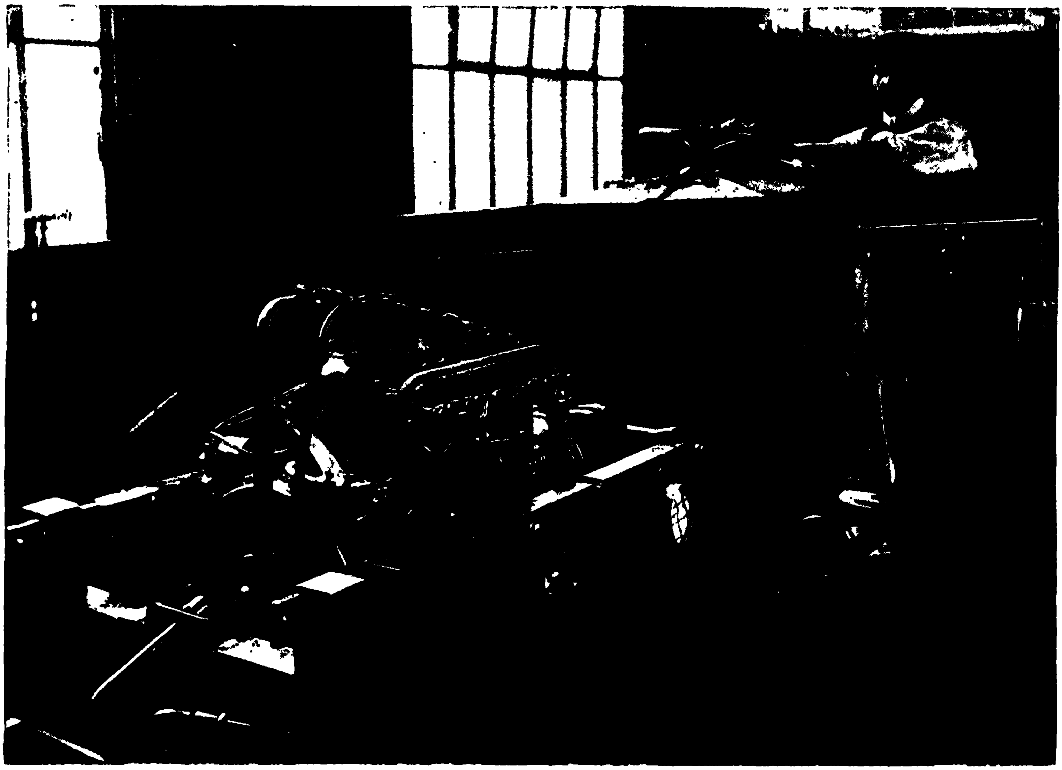
Let us now imagine the engine at rest, with the piston at the top of its stroke. A turn of the starting-handle—where that abomination is still employed—sets the whole process in operation. The piston is coupled, by means of a connecting-rod, to a horizontal crank-shaft below, and causes the shaft to turn and the fly-wheel to revolve. The turn of the handle draws down the piston, and at the same time opens the inlet valve. The suction induced by the descent of the piston causes the petrol-and-air mixture to be drawn through this valve-way into the upper half of the cylinder. The energy communicated to the fly-wheel suffices to carry the piston on its return journey up the cylinder on what is known as the compression or up-stroke stroke. The effect is to compress the gas to its utmost limit, so that when it explodes it shall



TESTING NAPIER ENGINE BODIES TO ENSURE PERFECT LUBRICATION WHEN WORKING

do so with the greatest possible elasticity. The moment the piston begins its upward stroke, the inlet valve closes to make the cylinder air-tight and admit of this compression of the mixture. As the piston completes its up-stroke a current of electricity, conducted into the top of the cylinder by way of a sparking-plug, causes a spark. An explosion of highly compressed petrol gas follows, and the expanding, exploding gas drives down the piston with great force, so setting the crank-shaft and fly-wheel revolving rapidly

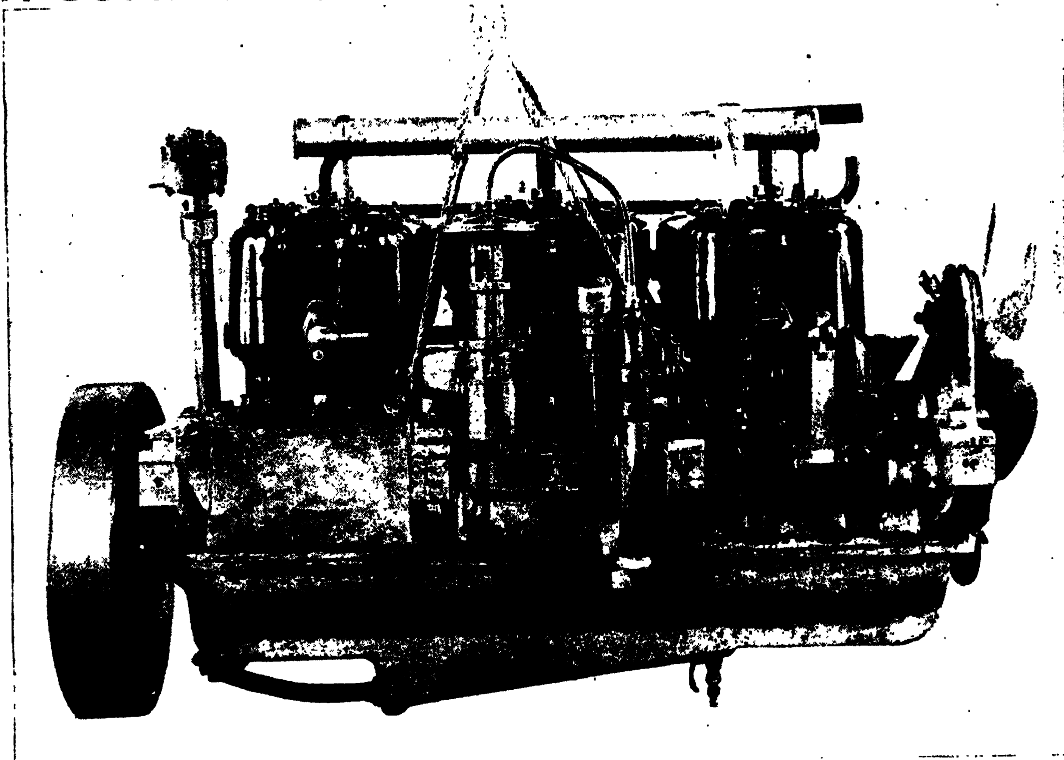
So far, we have followed three strokes—down, up, then down again. There is a contracts and noiselessly reaches the outer air. That is the cycle of strokes through which each piston again and again passes. By a beautiful system of timing, valves open and close, rise from their seating, to be pulled again into place by springs; sparks are produced at the psychological moment; the mixture is fired at precisely the right stage of compression; the fly-wheel receives its energy, and carries the pistons back to the top of the cylinders—all effected by the driver's giving a sharp tug or tugs at the starting-crank. There is the engine at work; now we have to transmit its power to the road-wheels to cause these



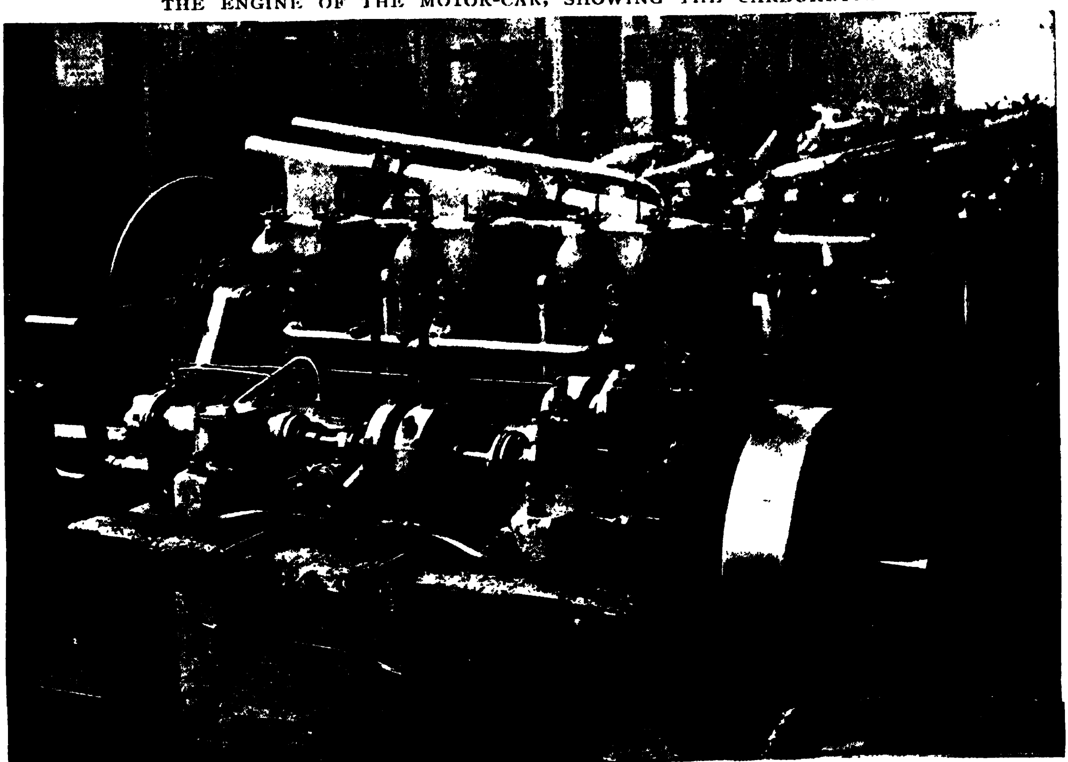
TESTING A COMPLETED ENGINE TO GAUGE ITS BRAKE HORSE-POWER

fourth to be described. And here we have to take note of a second valve in the head of the cylinder, on the opposite side to the inlet valve. The inlet valve has done its share by opening to admit the gas, and closing to make the cylinder air-tight. With the beginning of the fourth of the cycle of strokes, the exhaust valve opens automatically, so that the ascending piston has merely to push out the exhaust gas through the open exhaust valve. After leaving that valve the gas passes through a mechanism known as the silencer, in which it cools and to revolve and carry the car forward or backward, as we desire.

The fly-wheel, which is placed, as a rule, at the rear of the crank-shaft, is mounted upon a shaft that passes through the gear-box. Upon this shaft, which in the gear-box is square or castellated, are fixed gear-wheels that have to engage, at the will of the driver, with other gear-wheels connected with a second shaft—the cardan or propeller shaft, by which the power is conveyed to the driving-wheels. The first-mentioned shaft spins in unison with the crank-shaft.



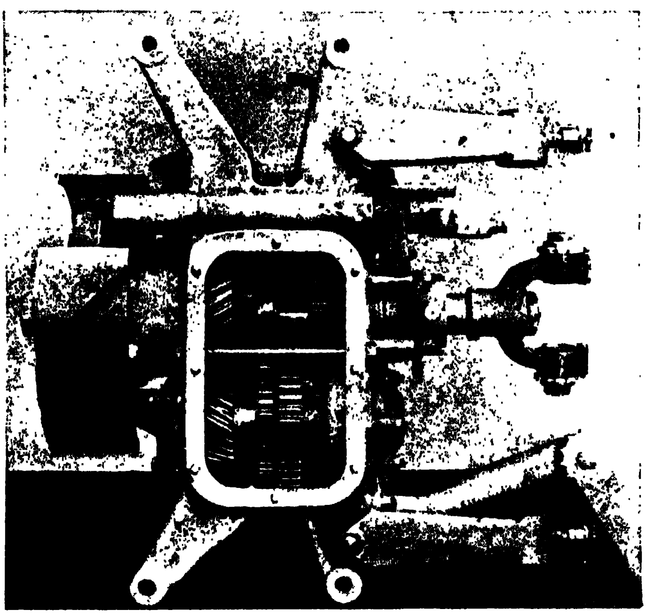
THE ENGINE OF THE MOTOR-CAR, SHOWING THE CARBURETTOR



THE ENGINE COMPLETED AND READY TO BE PLACED IN THE CHASSIS

but it is not yet linked up with the road-wheels. The engine runs free and the gear-shaft revolves as part of it. But by depressing a pedal the driver withdraws what is known as the clutch. This is of various types—cone, expanding discs, and so forth. The purpose of each is to engage with the interior of the fly-wheel, held in position there by the pressure of a strong spring. When the clutch is withdrawn, the shaft upon which it is mounted loses its speed, so that the gear-wheels it carries may be moved into position to enmesh with the gear-wheels on the propeller shaft. These wheels slide upon their shafts, but, as the latter are castellated, the wheels must turn with the shafts.

It is unnecessary to enter into a detailed explanation of the method of gearing. Briefly, the principle is that the main shaft, receiving its rotary impulse from the crank-shaft, communicates its energy to the gear-wheels on the secondary shaft. For slow speed a wheel of small size is enmeshed with a wheel of larger diameter, the size of the cogs being, of course, necessarily the same. To increase the speed we declutch again, allowing the engine to run free, and the car to be carried forward by its own momentum, what time we bring into mesh a wheel on the second, or driven, shaft that is only half the size of the one engaged on the propeller or driving shaft. It follows that if the driven wheel has but six wheel cogs, and the driving-wheel twelve, the sm[illegible]ller wheel must revolve at twice the [illegible]f the wheel that drives it. Another [illegible]ge of ratio brings about a further development, and there is a still higher in the case of a four-speed car. To reverse—[illegible]he car run backwards—a shaft [illegible] is introduced between two gear[illegible] the different shafts, and this has [illegible] of causing the propeller shaft to turn in the opposite direction, and to make the road-wheels run backwards instead of forward.



THE GEAR-BOX, SHOWING ITS TOOTHED WHEELS, WHICH GIVE VARIOUS SPEEDS

But all this time the car has been running, and we have traced our power only into the gear-box. The propeller shaft, which has received its power, through the clutch, from the engine, is linked up with the road-wheels, either through a counter shaft which drives chains by which the road-wheels in turn are made to revolve, or—and this is now the commonly accepted and better method for all save the heaviest vehicles—by what is known as a live axle. The rear axle of a motor-car is a complicated mechanism. To look at it, the novice, seeing it apparently fixed and rigid, like the axle of a horsed vehicle, must be puzzled to know how the road-wheels derive their energy. As a matter of fact, the back axle is not fixed; the front axle is. In the front the wheels turn upon a fixed axle, but the back axle revolves, although we do not see the movement. The actual axle is enclosed in a massive steel sleeve or sleeves. That is fixed, and carries the weight of the car. The real axle, to which the wheels are immovably keyed in the hubs, turns with the wheels. The whole mystery is enclosed in that vast gall fixed in the centre of the axle. Within that the propeller shaft terminates either in a bevel wheel, engaging with another bevel, or in a worm wheel and gear. The motion of the propeller shaft begins, as we have seen, in the gear-box. As it turns it drives the bevel wheel of the axle, causing the latter to revolve within its sleeve. According to the gears employed, so the speed of the propeller shaft and axle is governed. To check their action the clutch has to be withdrawn so that the gear shaft and the propeller-shaft, dependent upon it, cease to revolve, while, further

to accelerate the stoppage, brakes may be applied—one, the foot-brake, gripping a drum on the propeller shaft; the second, controlled by hand, acting on drums on the road-wheels.

Everything is plain, then, for straight running. But we have all sorts of corners and curves to negotiate, which mean that the outer road-wheel, having the greater distance at the moment to travel, must revolve at a greater rate than the inner wheel. To understand this we have only to watch a line of soldiers at drill. When the order to turn is given, the men at one end of the line practically mark time, while those at the opposite end bustle round almost at a double. The principle is the same with the two road wheels. Unless allowance for this were made, serious strain and danger would accrue. We have, then, what is known as the balance or differential gear. To bring about the desired result, the axle is built up in two equal halves and then connected by the gear named. Each half of the axle has its big bevel wheel, driven by the mechanism of the propeller shaft, so that both revolve at a uniform pace, but small pinions, enmeshed with the two big bevels, revolve when one road-wheel turns faster than its fellow, and give the compensation necessary. There is a variety of differential gears, and the mechanism is difficult to explain without extended technical detail and diagrams of the most elaborate type.

So far we have said nothing about such vital points as lubrication and cooling. In order that the engine may not become overheated each cylinder is water-jacketed. The water circulates from the water-jackets through a radiator, which is cooled either by the rush of air between its gills or cells, or by air drawn through it by the action of a fan mounted behind it. Oil is forced to all parts of the engine under pressure by a variety of ingenious methods, though there remains a score or so of points of the chassis to which the driver must himself

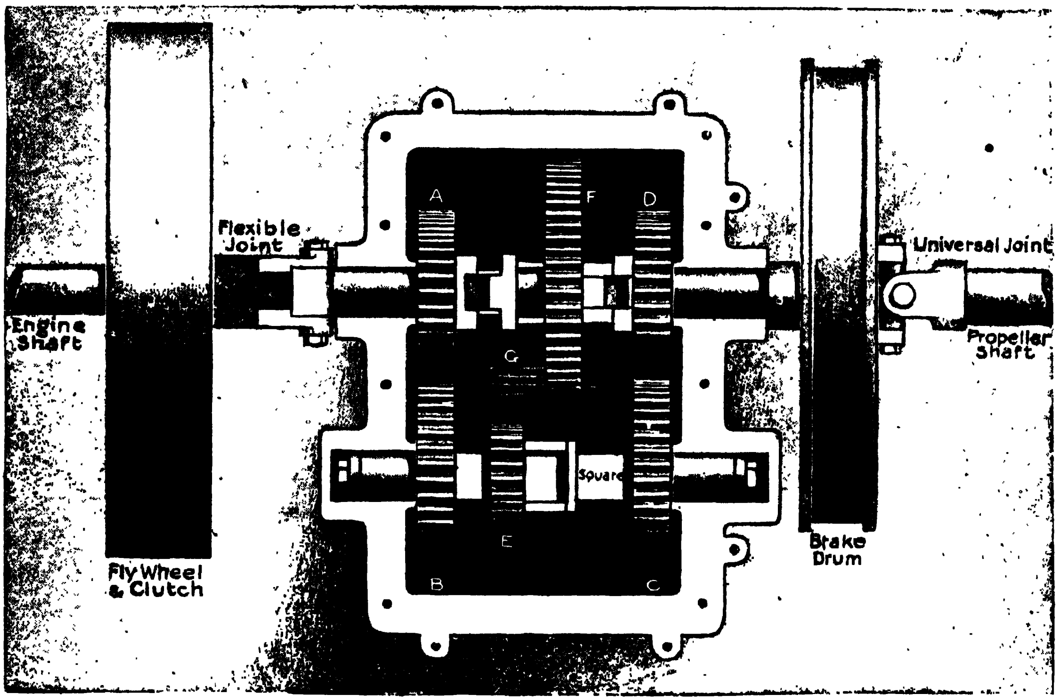


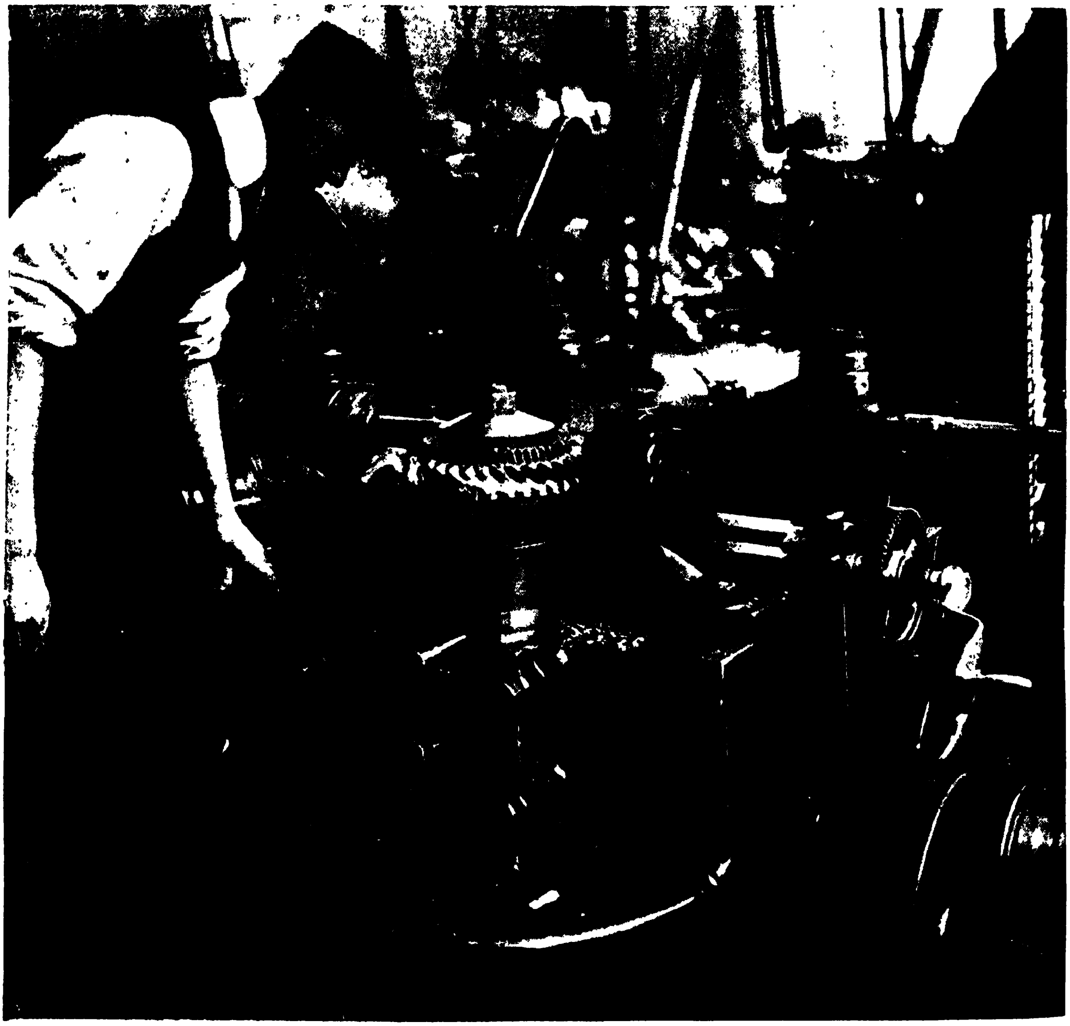
DIAGRAM SHOWING HOW DIFFERENT SPEEDS ARE OBTAINED THROUGH THE GEAR-BOX

This illustration shows a gear-box that has three forward speeds and one reverse, for backing the car. The cog-wheel A is mounted on a hollow shaft, driven by the clutch. Into this hollow shaft projects another shaft, on which is fixed cog-wheel F. Cog-wheel F slides backwards and forwards on its shaft. Cog-wheels B and C are always in mesh with cog-wheels A and D respectively. Cog-wheel E can be moved to right or left along its shaft, so as to engage or disengage with cog-wheel F. When the engine is working, A revolves B, B revolves C and turns D, which is loose on its shaft. For the first or lowest speed a lever is moved, which slides E into gear with F. Then the gears work as follows—A turns B, B turns E, E turns F, and F turns the propeller shaft. For the second speed, a lever disengages E and F, and F is moved to the right till its projections interlock with slots on D, causing D to run no longer idly on its shaft. The drive is then through A, B, C, D. The third speed is obtained by pulling F to the left into connection with A; this couples the engine-shaft direct with the propeller shaft, and gives the direct drive. For reversing, a cog-wheel, G, which is beneath E and F, is raised into gear with them. The drive is then A, B, E, G, F. An odd number of wheels being now engaged, the propeller shaft turns in a reverse direction to that of the engine. The gear-box is shown with the upper part removed.

apply oil or grease. So much, then, for the car in running.

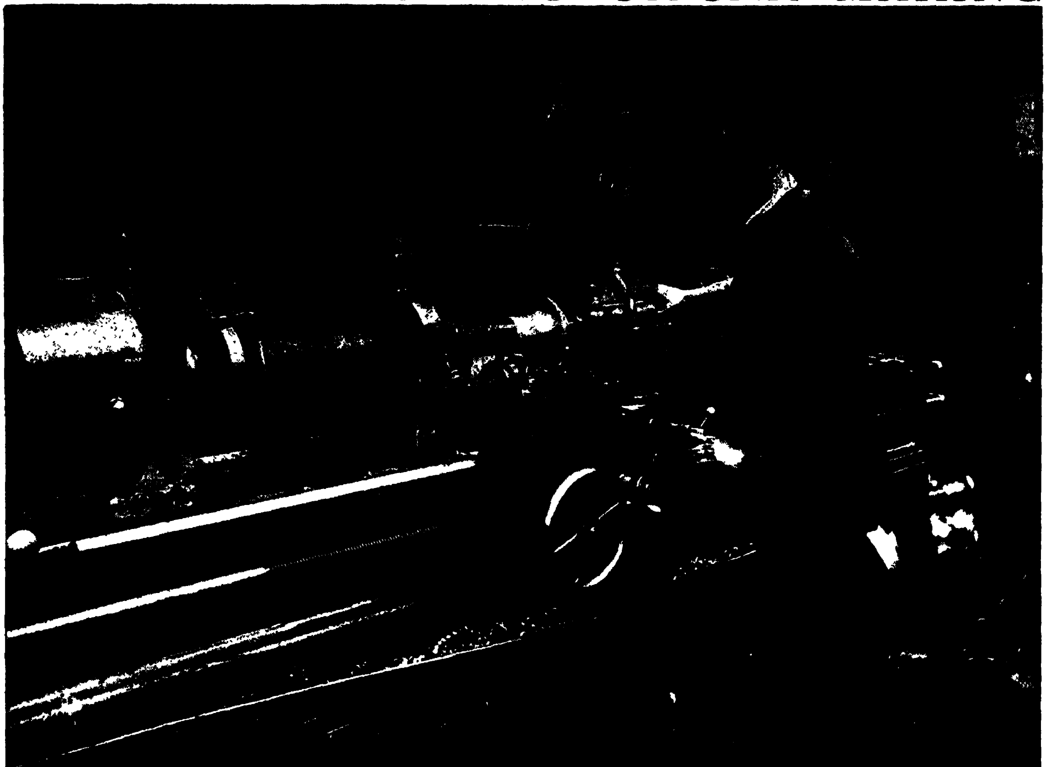
To see it rising into shape from masses of crude metal and other material is an educational opportunity which every car-owner should welcome. The processes whose description follow relate to the Napier works, permission to view which was sought from the fact that this firm ranks, with two or three others, as the foremost not only in Great Britain but in the world. The man who enters the works expecting to follow the entire sequence of operations, from the raw steel to the finished car, will be disappointed. He sees a world of machinery and a forest of belting and hosts of men engaged in complicated tasks. He recognises part after part of a car, and follows each through its cutting and lathing, and grinding and testing, and marvels at the infinite delicacy and exactitude with which every element of the machine, from the mighty crank shaft of a six-cylinder car to the minutest part of the carburettor is treated. And then he understands why English cars of high grade cannot compete in price with the American article.

Every nut and bolt and screw, after being gauged by the man who turns it, is carried to the testing-room, there to be examined by the experts of the firm. Every bit of case-hardening is passed through a gauge, which tests up to a pressure of 4000 kilos. A microscope, which forms part of the machine, reveals the depth and diameter of the indentation effected. Every ball for the ball-races is submitted to a similar examination. The



CUTTING THE WORM-WHEELS WITH A POWERFUL MACHINE-TOOL

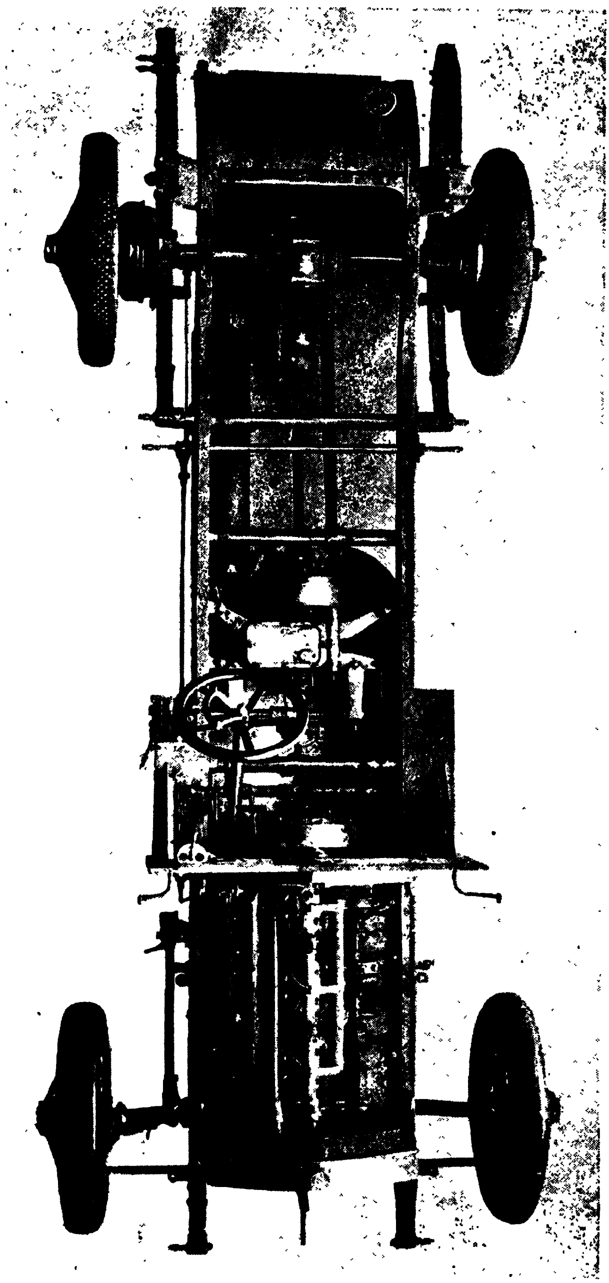
MACHINERY FOR MOTOR-CAR MAKING



TURNING THE AXLE OF A MOTOR-CAR FROM A FORGED STEEL BAR

THE MAGNETO CHUCK, WHICH GRIPS TO ITS FACE SMALL METAL ARTICLES FOR GRINDING

rollers employed in certain bearings have to be exact to ten-thousandths of an inch; to be three ten-thousandths out means the rejection of the particular roller. The crank shaft, which is forged from a solid bar of the finest steel, is cut by lathe, then ground by emery-wheels revolving with a peripheral speed of 10,000 feet per second. Every crank shaft is numbered and submitted to tests for all sorts of stresses. A section is cut from the end, tested for tensile strength, and kept with a full record entered in the books, so that at any moment the history and pedigree of a given crank shaft can be turned up. In this department other tests are applied, and one, for impact shock, is notable. The part to be tried—probably a front axle—is placed in a machine which is set to work and left to itself, it may be for a day or a night. It simply and solidly hammers, at a known force, hammers and hammers upon the piece of metal given into its power. It records the number of blows delivered; and should a break be effected, the machine comes complacently to rest, for the one blow which goes through enables the hammer to touch a trigger, and by electric impulse bring the whole operation to an end.

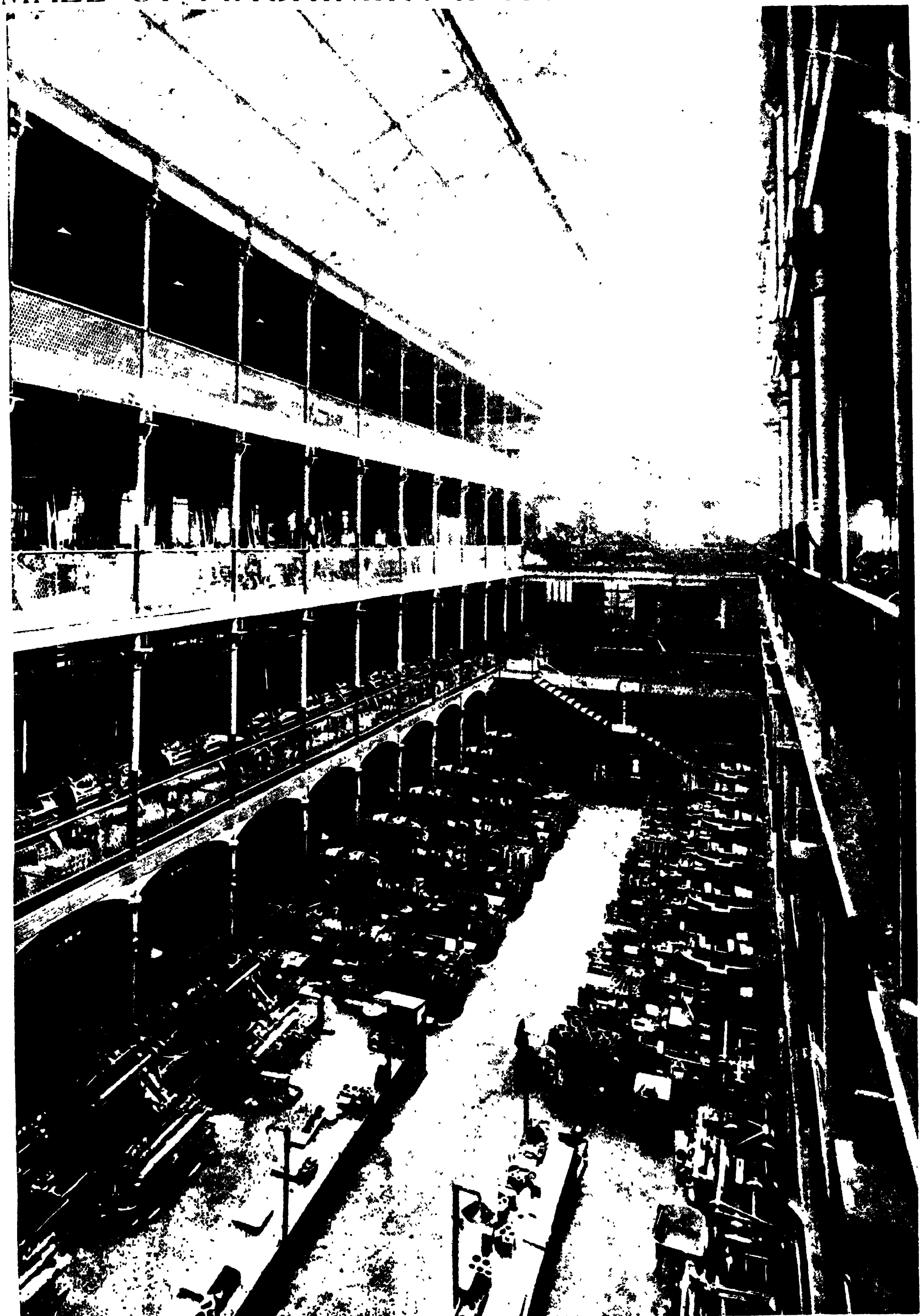


HOW THE MECHANISM LIES IN THE CHASSIS

The making of the gear-box is another elaborate process. Men's hands cannot be entrusted with the boring of the various channels required. This is carried out by a machine which receives the gear-box into a sort of steel chamber, where it is held while refined appliances direct the boring. The base chamber, too, has to stand a water test of 60 pounds to the square inch before it is declared non-porous and capable of safely containing the oil with which it will be charged. Indeed, the whole system of testing is unique when the size of the vehicles is considered. Infinite care is taken with the gauges with which each man works. These are corrected weekly by the firm's standard gauge, kept in a room in which the temperature is a constant sixty degrees, and registering up to one hundred-thousandth of an inch. The Napier firm is justly proud of its reputation for gauges, for in the manufacture of these it was distinguished long before motor-cars came into being.

As has been said, some 200 machines go to the making of a single motor-car, and some of these are remarkable. One, called the magnetic chuck, on receiving a current of electricity, grips to its face any small metal article which has to be ground, and could

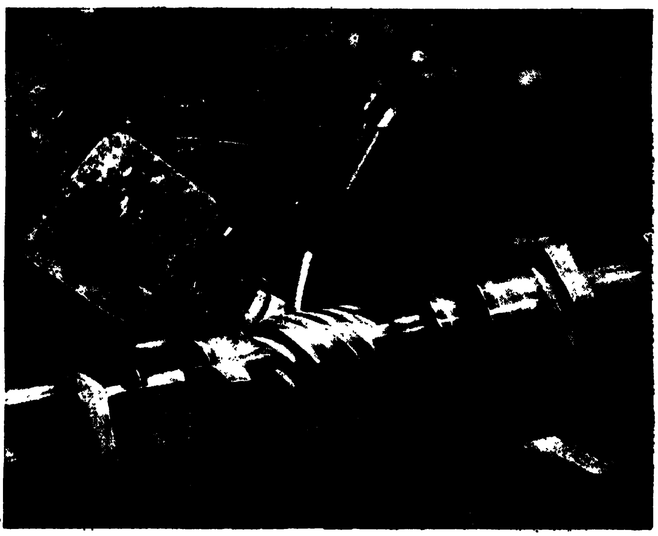
MAZE OF MACHINERY IN A MOTOR FACTORY



A GENERAL VIEW OF A VAST HALL OF MACHINERY IN THE DAIMLER MOTOR WORKS

not otherwise easily, and without fear of damage, be retained in position. Another cuts a solid bar of steel of portentous weight into the half-section of a back axle, while yet another tunnels through a still larger bar to form the sleeve for the axle itself. Hard by, another masterpiece of mechanism makes its castellated boring through the heart of the gear-wheels, while, further along, the shafts themselves are having their castellated six-keyways cut, as easily as if they were rods of whitewood. In one division we see the actual engines taking shape; in another we see their parts being cut and ground and made true. Finally, we find the engine itself, just recently so many metal parts, put together and starting into life. It is on a bench and at work, singing away like the merriest of sewing-machines, though not half so noisy, running for all it is worth, simply to make its parts run sweetly after they have come from machines that have cut them while one waits.


LEATHER CHIPS FOR HARDENING THE STEEL


TURNING THE WORM-THREAD

There is a superb nonchalance about these machines—vast masses of metal and complexity, all designed to effect a single purpose, that their cutting part may move backward and forward with unerring accuracy, paring away at each forward thrust a shaving of metal from the disc that is to become a gear-wheel. It receives a disc of phosphor-bronze, we will say; is left untended, and quietly and without fuss or noise eats away just so much and no more, then goes on to another geometrically defined position and eats away another portion. Even more surprising still is the machine which cuts the famous Napier worm-wheel. This takes the place in the Napier live axle of the bevel, and yields sweeter and more silent running. The worm has been abandoned, in some instances, as difficult accurately to make. The Napier house has always been more fortunate in the matter.

To return, however, to the engine, which is running itself to silence. When it pleases the ear of its masters, it is removed from the bench, taken to pieces, examined in every part, washed in paraffin under high pressure, and, if perfect, reassembled and then tested for brake horse-power. In a single room there may be from a dozen to a score or more engines at work, fed from conduits with petrol and with water for their cooling, and each racing as if mounted on a chassis and doing its sixty miles an hour. Each has to drive a shaft to which a brake with a powerful gauge is affixed. The engine works against the pressure of the brake, and the resistance offered

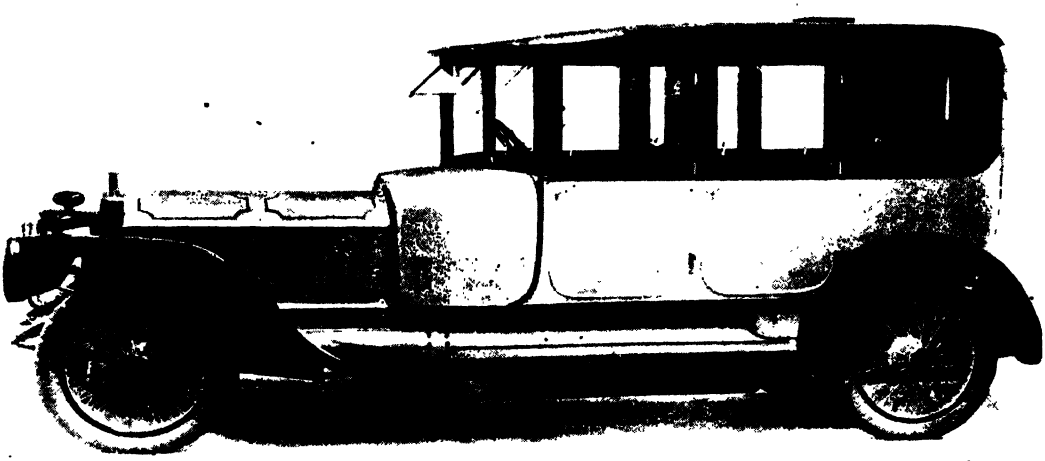
by the latter is recorded by the gauge. Thus the exact power of every engine that leaves the works is known, though the Revenue authorities may not be invited to fix their tax in accordance with the figures shown in that room where engine secrets are read.

It is not until the assembling-room is reached, and the engine is placed upon its chassis, that the lay mind realises that it really is a motor-car which has been slowly coming together from the machines which are drilling and lathing, grinding, polishing, and burnishing. Not a tithe of the processes has been described. New improvements are constantly being added, all with a view to greater exactitude if such be possible, to the reduction of friction, the lessening of noise, and so forth. Even so small a thing as a baffle-plate has its own special machine. It was necessary, formerly, to rivet together the several metal plates composing this device. Today the Napier company has at work an electrical fusing-machine, through which a powerful current passes and instantly generates at the point of contact so terrific a heat that the sheets of metal become one, with never a riveter's hammer near them.

Every part of a motor-car requires strength of a special character. Some must be capable of withstanding shocks, some must resist friction, some must be equal to great torsional stress. One part may require two different types of strength—toughness at one end, hardness at the other, or hardness of exterior with toughness of core.

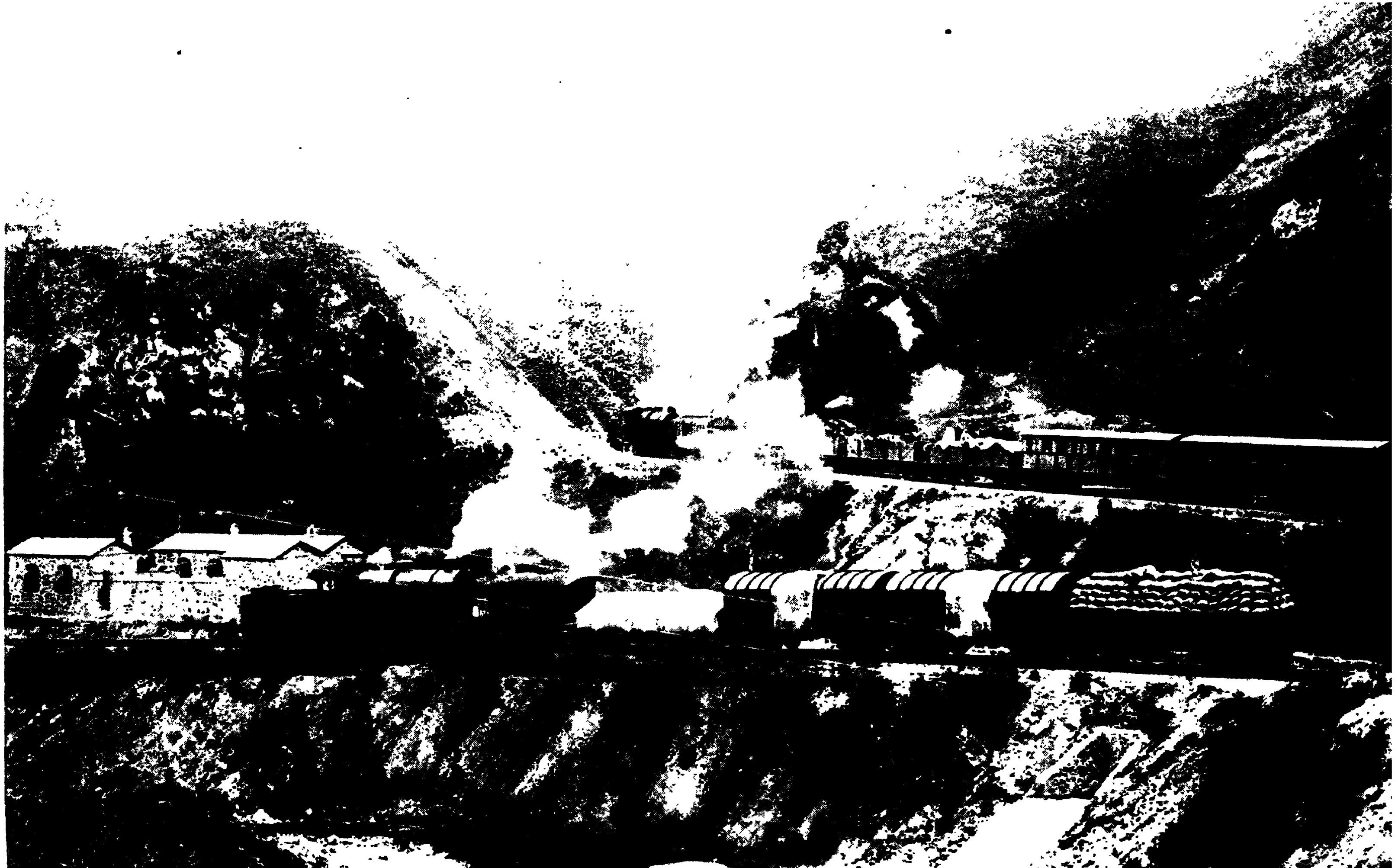
The methods by which these results are obtained are highly interesting. The part to be treated has already received its shape from the mechanic. It is now embedded in a crucible filled with chips of leather, and placed for nine hours in a coke-furnace, whose temperature is recorded minute by minute upon a pyrometer under the watchful eye of a foreman. At the end of the ninth hour the steel emerges, very hard and brittle, having increased in carbon content from, say, ·2 to ·9 per cent. It is now placed in an oil furnace, the temperature of which is maintained at about 800 degrees Fahrenheit. In this heat the atomic constitution of the steel undergoes a further change, and it is now tough as well as hard.

These are among the processes comprised in the making of an English motor-car For seven months the labour of 250 men and the operation of 200 machines are involved. The body-builder has still to do his work, but there is little of interest here for the man interested in the machine. Finally, the result of all is that wonder of mechanism which stands purring at the door, ready to fly, at the touch of pedal and lever, to the remotest village in the farthest county, or to carry us with unerring precision through the thickest traffic in London's most crowded hour. There may be more wonderful things than a motor-car, but there certainly is none in the history of travel. It enables a man to scoff at distance and laugh at inadequate train-services in any part of the land.



THE COMPLETED NAPIER CAR, READY FOR THE ROAD

THE CAPITULATION OF REMOTEST CHINA TO THE GREAT IRON ROAD OF CIVILISATION



THE SWITCHBACK IN NANKOW PASS, ON THE PEKING-KALGAN RAILWAY, A LINE BUILT SOLELY BY CHINESE ENGINEERS AND CHINESE CAPITAL

THE FUTURE OF TRADE

How the Trade that is to be will Dwarf the Trade of the Present Day

THE AMPLE ROOM FOR ALL COMPETITORS

THE future of British trade, whether considered as the trade of the United Kingdom or as the trade of the British Empire, is a subject which nearly concerns our proper pride. In the past, great Empires have risen and flourished for centuries, and then faded to mere names. What prospect is there of security and permanence for the trade of the United Kingdom, and for the integrity and commercial importance of the British Empire?

As far as the United Kingdom, and, indeed, any great modern nation, is concerned, the fear of destruction by conquest has passed. Gone for ever are the days when a Nineveh or a Babylon or a Carthage could be reduced to heaps of ruins. The conquerors of the twentieth century, if there are to be any, will know that a conqueror gains less than nothing by destroying that over which he triumphs. The possibility of war between two or more of the Great Powers of Europe still unfortunately remains, but fortunately there does not remain the possibility of the armies of a conqueror reducing to ruins the cities of the conquered. Indemnities may still be demanded of the conquered, but there is no question of permanent tribute as in days of old, and even the payment of a very large indemnity leaves intact the productive powers and incorporated wealth of a nation. The payment of a war indemnity is a thing to be feared, but it is not an irreparable disaster. We hope we shall not be misunderstood in saying this. We do not mean that the payment of a huge indemnity after conquest in modern times might not check the progress of a nation for years, for decades, or even for a quarter of a century or more; we are only desirous of pointing clearly to the fact that ancient conquests and modern conquests are very different in their character and effects.

However little Man may have learned in some respects since the barbarians entered Rome, one insensate conception, at least, has gone for ever, and it is that a nation or an empire can remain great by virtue of tribute drawn from the conquered. Indeed, we have come to know that tribute leads to the decay of those who receive it. The British Empire does not stand by virtue of tribute drawn into the United Kingdom from conquered peoples or colonies; on the contrary, the protection of the British Empire is a great drain upon the taxpayer of the United Kingdom, since he, for by far the greater part, sustains the sea power which holds the Empire together. This maintenance by the Imperial power would have seemed a strange and absurd conception to the Roman, who drew to Rome from a great Empire the tribute of food and commodities which provided the *panem et circenses* which worked such havoc with the fibre of the Romans.

If, however, there is no fear of the disintegration of the United Kingdom, we cannot affirm that the British Empire as a whole has yet reached a condition of complete security and stability. If the reader will turn again to page 1114, Chapter 9, he will see that, upon a near estimate, the British Empire in 1911 (the facts are not substantially different in 1912 or 1913) had only about 60,000,000 white people in its far-flung territories—*i.e.*, 45,000,000 in the United Kingdom, and less than 15,000,000 in all the Britains beyond the seas. The total population of the Empire is enormous, over 400,000,000, but the white population is comparatively small, and, furthermore, it is widely scattered over an enormous area, divided by many seas. It thus compares with the populations of other great countries, the approximate figures given relating to the period 1911–12.

WHITE POPULATIONS OF NATIONS

	Approximately.
The British Empire	60,000,000
The German Empire	66,000,000
The Russian Empire (in Europe only)	110,000,000
The United States (Of the total about 95,000,000—fully 10,000,000 are negroes, Indians, or Asiatics.)	85,000,000
Austria-Hungary	50,000,000
Italy	35,000,000
France	39,000,000

The peopling of the British Empire with a very much larger number of whites stands out as one of the most important problems of British statesmanship. Somehow or other, the great new territories of the Dominion of Canada, the Union of South Africa, the Commonwealth of Australia, and the Dominion of New Zealand must secure much greater populations. If they succeed in doing this, if, during say the next quarter of a century they raise themselves numerically to the status of great peoples, and if in the meantime the British taxpayer makes the sacrifices which are necessary for defence, then the permanence of the Empire will be secured. Indeed, failure in the task is not to be contemplated, for it would be one of the most tremendous failures in the history of all mankind.

The World-Wide Wrong of Leaving Lands Undeveloped

We shall do well to bear in mind that the world as a whole needs the full development of all her territories. Nations or empires which, either from lack of good government or from lack of native genius, fail to develop their material possibilities do the world injury, and the world is justified in depriving them of their rule. There is no value in the conception that, because some backward people or some unworthy Government has in nominal possession, by inheritance or by acquisition, a certain portion of the earth's territory, that possession must be recognised by the world as a whole as an indefeasible and inalienable right. Briefly, the world must be used for the general good of mankind, and any people which does not properly use that part of the world in which it lives is not merely doing a wrong to itself but to the world at large. The amount of land area on the globe is, after all, exceedingly limited in quantity, amounting to no more than about one-fourth of the world's surface, and much of it is desert, or ice-bound, or otherwise useless. Now that we are learning to do things on a large scale we are already beginning to feel how smal the world is. We are realising more an more that mankind cannot afford to leav derelict any part of the world.

The case of "new" countries is of specia importance. These have comparatively vas stores of raw material and undevelope natural resources. They have ampl room for hundreds of millions of peopl instead of the few scattered million who at present occupy them.

The Need for Peopling Empty British Lands from Crowded British Cities

It is very difficult for us to realise that al Canada has as yet only about as man people in it as Greater London; that th people in New Zealand do not number ver many more than the people of Glasgow and that the London County Counci area has as many people in it as th great island-continent of Australia. Ther is an obvious duty upon those who ar responsible for such new and undevelope lands, and it is that those lands shoul be brought into full bearing; and that cannot be accomplished without mor people. This raises the point: What sort of people?

If the British Empire is to remai British, it is obvious that it can only do s if the white immigrants into the Britis Dominions are, as to a majority, draw from the United Kingdom. That leads u to inquire what sort of a surplus of popula tion the United Kingdom has to draw upon. Inquiry shows that the British birth rate has been very rapidly falling, but that against this there has to be put an excellent decrease in the death-rate. In spite o the prevention of disease and of muc saving of life, however, the natural increas of the United Kingdom in 1912—*i.e.*, th surplus of births over deaths—is not mor than about 450,000, and it will at once b seen that this does not form more than a very limited reserve upon which the Britis Colonies can draw for immigrants.

The Danger of the Extremities of the Empire Weakening Its Heart

They are, however, spending huge sum of money to tempt British citizens acros the seas, and they are succeeding so wel that the new emigration statistics, com piled since March, 1912, show that, in th seven months April-October, out of 289,01 emigrants who left the United Kingdom as many as 211,000 went to British Posses sions. The Colonies are thus drawing fro the Mother Country a very large part o what surplus she can spare, and mor

cannot very well be drawn with safety. If three Colonies were to draw 150,000 per annum each, in addition to smaller calls from other countries, the population of the United Kingdom would begin to fall, and that would be a very serious matter; the British Empire under such conditions would be strengthened at the extremities, but weakened at the heart.

An adequate peopling of the British Empire is thus seen to be a very serious problem indeed. We must do all we possibly can to reduce the British death-rate still further. If it could be reduced from 14 per thousand to 9 per thousand it would mean the saving of about 225,000 lives per annum, and that would make a great deal of difference to the question. We ought not to regard this as an impossible ideal, for the death-rate of New Zealand is only about 9 per thousand, and the death-rate of many healthy parts of the United Kingdom is no more.

Of course, the Colonies need not restrict their immigration solely to people from the United Kingdom, and in actual fact they are not doing so. Like the United States, they draw from all the world, and the various elements are for the most part absorbed without any great difficulty. Let us note what has been accomplished by Canada in obtaining population in the last forty years.

THE GROWTH OF CANADA'S POPULATION

	Population.	Increase in Decade.
1871	3,500,000	—
1881	4,300,000	800,000
1891	4,800,000	500,000
1901	5,400,000	600,000
1911	7,200,000	1,800,000

It will be seen that in the decade 1901-1911 Canada gained almost as many people as in the previous thirty years. The rate appears to be still increasing, and by 1921 it is possible that the Dominion may have 11,000,000 people.

Now let us look at the facts as to the Australian population. It will be seen from the following particulars that in the decade 1901-1911 Australia gained only 700,000 people. She is now hastily seeking immigrants after having for some time discouraged them, and there is no doubt that the next decade will see a very large increase in her population.

POPULATION OF THE COMMONWEALTH
Exclusive of Aborigines

Census of	Population.	Increase in Decade.
1881	2,200,000.	—
1891	3,200,000	1,000,000
1901	3,800,000	600,000
1911	4,500,000	700,000

It is impossible to exaggerate the importance of the considerations which arise from our broad study of the Imperial Population. There are other great nations seeking outlets for trade and population, and, as we have said, the world must be fully used in the interests of all the world. If, therefore, the British Empire fails in its primary duty of peopling and developing its vast resources, it will fail because it deserves to fail. Fortunately, there is every sign that the importance of the question is being recognised both at home and in the Dominions, and year by year the position ought to grow safer. In the interim, before the task is accomplished, the danger to the British Empire lies in the fact that it is scattered about the world, *and therefore either divided or united by the great seas.* Everything in this connection depends upon the retention of the command of the sea, and already there are signs that the great Dominions see the necessity of sharing with the British taxpayer the herculean task of maintaining that command.

If we failed in this very material task, the consequences to British trade would be exceedingly serious. No other nation is in our peculiar position. If we can bring ourselves to imagine for a single moment the defeat of British sea-power, and the consequent sundering of the widely divided Britains, we can see that many great markets would be endangered. We have now, for example, the lion's share of the trade of India, and we have it not because we enjoy special privileges in the Indian market, but simply because India has open ports to the goods of all nations. If we lost India, however, we might lose tens of millions of pounds' worth of trade through the imposition of differential tariffs by India's new possessor. The same remarks apply to Egypt, which is at present, for practical purposes, under the protection of the British Crown. With regard to Australia, it is difficult to see how the island could protect itself, with its tiny and scattered population, if the British Empire

ever lost command of the sea. It really would not be a very difficult task for some other Great Power to hold it by military force, and to alter its nationality by an organised system of emigration; the thing might be easily effected in a decade as a hard matter of simple business organisation.

The conquest of Australia by a foreign Power would not mean that that Power would draw tribute from Australia, but it would probably mean the setting up of an Australian tariff which would strike heavily at British trade. If this occurred, the loss would not be so great as in the case of India, but it would be severely felt.

Thus, although modern conquest does not mean a loss to the conquered of the kind that it meant in the old days, it is still true that it may mean heavy and irreparable loss. As far as the particular case of the British Empire is concerned, and that is the case which chiefly interests us, it is abundantly clear that the conquest of the United Kingdom would not merely be a loss of prestige or of national pride, but that it would be a great material loss. Not only the Empire but the great trade between its various parts almost certainly would be shattered.

It is necessary to dwell upon this because the trade of the United Kingdom, we have always to bear in mind, is of a quite exceptional character. The sustaining of 45,000,000 of people in the British Isles is by way of being an industrial miracle. As we saw in the last chapter, England and Wales in the middle of the eighteenth century had *only about* 6,000,000 *people*, whereas now they have leapt upward to about 36,000,000 people.

We saw that this marvellous growth resulted from successful manufacturing, and we have always to remind ourselves that we cannot manufacture without materials, and that we have to win from abroad imports of things we do not posses ourselves. That is to say, we have t sustain an enormous export trade in orde to win imports for our population to worl upon and to feed upon. It would be n light matter for the people of the Unite Kingdom if there came such a shock t British trade as would be administered b the severance of great and prosperou markets, and their control by foreig nations who might apply differential tariff to them. There is also the exceedingl important matter of the British mercantil marine. The loss of the command of th sea might easily mean the loss for eve of our maritime supremacy, and th services of our ships, as we have shown pay for over £100,000,000 worth pe annum of our imports.

To sum up the matter from a trade poin of view, the United Kingdom is a well populated country whose prosperity i bound up with oversea commerce. It i the head and front of a great and widel scattered Empire, only a small proportio of the inhabitants of which are whit people. The integrity of the Empire an the safety of its trade are sustained b sea-power, the cost being almost entirel borne by the Mother Country. The self governing Colonies have great areas bu tiny populations, and until they hav grown considerably their individual positio is weak. It is necessary to develop al "new" countries, and the responsibility o the British Empire to the world is accord ingly great. It is the primary duty of th British people to develop and to populat the Empire, and to make whatever sacrifice are necessary to maintain sea-power in th near future, while the Britains over th seas are gaining their necessary populatio and economic growth. If this duty is no fulfilled it may go hard, not only with th Imperial unity, but with the actual trad and material prosperity of the Unite Kingdom as a community.

A BRIEF VIEW OF THE GROWTH OF BRITISH COMMERCE IN HALF A CENTURY

Year.	Imports.	Exports of British Goods.	Re-exports of Imported Goods.	Total.
	£	£	£	£
1860	210,000,000	136,000,000	29,000,000	375,000,000
1870	303,000,000	200,000,000	44,000,000	547,000,000
1880	411,000,000	223,000,000	63,000,000	697,000,000
1890	421,000,000	264,000,000	65,000,000	750,000,000
1900	523,000,000	283,000,000	63,000,000	869,000,000
1910	678,000,000	430,000,000	104,000,000	1,212,000,000
1911	680,000,000	454,000,000	103,000,000	1,237,000,000
1912	745,000,000	487,000,000	112,000,000	1,344,000,000

Apart from any abnormal blow at British commerce, such as might arise in the circumstances described, what are the prospects of British trade? Writing at the end of 1912, we have the complete trade returns of that year before us, and we are able to affirm that never before has so much oversea commerce been transacted by the United Kingdom, whether it be measured by volume or by value. Let us remind ourselves of the facts of the case. On the last page is a very short account of the movement of British oversea trade in the last half-century.

We see that in the exceptionally good year 1912 far more oversea commerce was transacted than ever before. Even as compared with 1900, which was a year of very good trade, there was an increase of £475,000,000. These figures are, of course, eminently satisfactory, but they become even more so when we remember that the great increases have been made in a world in which competition has been rapidly developing. This is a most important point. American and German competition did not really begin to develop seriously until towards the end of the nineteenth century. It arose as soon as America and Germany began in their turn to make proper use of their coal powers. When they did that, their progress was assured. It is in view of these circumstances that we have to consider the above record of British progress. Let us see how American, German, and French trade has moved since 1880. The facts to the end of 1911 are given in the table at the foot of this page.

The figures of Germany and of America, if not those of France, show remarkable progress. A moment's thought will show that this fact, instead of detracting from the excellence of the British figures, rather enhances it. We see that our own progress has been achieved contemporaneously with foreign progress. That has a profound significance when we consider the possibilities of the future. Let us think what the position would be if we found, on examining the records of other nations, that they had all been stationary, while we alone had made progress. Such a condition would lead us not improperly to the conclusion that the trade of the world had very definite limits, and that our own progress had made it difficult or impossible for other nations to "get on," there being only so much trade, and the gain of one nation therefore being the direct and consequent loss of others. Surely, therefore, it is a much happier thing to find the figures of the United Kingdom and those of her chief rivals rising together, and thus giving conclusive evidence that there is plenty of room for them all. It is a conclusion which is supported by many other pertinent circumstances.

If we regard the world as a field for railway enterprise, for example, we see that large parts of it are as yet scarcely touched by the railway engineer. A few countries have many railways, but the greater part of the countries of the world are as yet but poorly supplied with organised means of rail locomotion. Here alone is an enormous field of work to be exploited. The needed railways will have to be built, and the world's manufacturers will be called upon to supply the enormous amount of material required. There seems to be plenty of room for all countries capable of doing the work to share in it, and in respect of this great industry it therefore in no way appears that the growth in exports of one country will necessarily mean the loss of exports by another country.

Thus also it is with other forms of locomotion. The cycle has become a commonplace with people of small means in, at present, a few countries only. We refer to the ordinary bicycle which has to be pedalled by the rider. Every year we add enormously to the existing market, which is actually great but relatively small when compared with the possible number of bicycle riders in the world.

THE IMPORTS AND EXPORTS OF UNITED STATES, FRANCE, AND GERMANY.

	United States		France		Germany	
	Imports	Exports	Imports	Exports	Imports	Exports
	£	£	£	£	£	£
1880	130,700,000	171,700,000	201,300,000	138,700,000	138,600,000	142,400,000
1890	161,800,000	176,100,000	177,500,000	150,100,000	204,600,000	163,600,000
1900	172,100,000	285,600,000	187,900,000	164,300,000	283,500,000	226,700,000
1910	325,600,000	381,000,000	286,900,000	249,400,000	439,100,000	367,500,000
1911	319,400,000	428,800,000	326,400,000	246,800,000	469,300,000	398,300,000

It is unnecessary to suppose, therefore, that the growth of foreign cycle factories must necessarily mean the decadence of British cycle factories, or *vice versa.*

With differences of degree the same remarks apply to road vehicles of all kinds which are propelled by motors, whether they are cycles or miniature run-about cars or full-sized motor-cars. These trades have grown very rapidly in the last ten years, but their growth so far is a little thing compared with what they are destined to experience in the future, when there will be a larger production of wealth in the world, and when all the roads of the world will be freely used by motorists. It is more than probable, too, that the arts of aerial navigation will create industries of gigantic dimensions in the time to come. These are new industries, but what is true of them is true, more or less, of ancient or well-established industries also.

Even in Europe there are tens of millions of families whose lives are still lived in a most primitive fashion, and whose command of the products of modern industry is insignificant. Who can doubt, however, that in the twentieth century the potential needs will develop into active demands, and that the stream of international trade will be accordingly swollen? And if so many people in Europe are still poor buyers, what are we to say of the hundreds of millions of Asia and Africa? Trading with these places is at present of comparatively small dimensions, and, in regard to some parts of them, quite insignificant. There are great fields for development in the two continents, which will undoubtedly become exceedingly fruitful during the present century, and which will give to all trading nations the opportunity greatly to increase the volume of their business transactions.

Then there are the fertile lands of South America, which, as we have only just begun to realise, are to be counted amongst the world's most important markets. The nations of South America are growing with such extreme rapidity that one has constantly to refer to their records if one does not wish to be inaccurate in statements concerning them. Their railways and their crops, their sheep and their cattle, are ever multiplying, and a plentiful immigration from less favoured lands is constantly augmenting their powers of production. Here is an account of the progress of the imports of some of them in 1900 and 1910.

IMPORTS OF SOUTH AMERICAN NATIONS

	1900	1910
	£	£
Argentina	23,400,000	70,400,000
Brazil	21,400,000 (1901)	47,600,000
Chile	8,000,000	22,300,000
Uruguay	5,300,000	8,000,000
Peru	2,100,000	4,000,000
Bolivia	1,000,000	3,700,000

These remarkable figures help us to understand the expanding commerce of the European nations. We see clearly how rapidly new customers are arising beyond the seas. We are not to regard the present development of these South American cities as more than a pale shadow of what their future holds. Where their commerce is now counted in tens, it will undoubtedly come to be counted in hundreds. Thus again we have a picture of our exporters not battling for a share in a world the trade of which is narrowly circumscribed, but trading in a world which, for practical purposes, is of unlimited promise to all efficient traders.

Europe, the cradle of white civilisation is year by year exporting many of her citizens to the New Worlds of America and Australasia. This also has much to do with the rapid growth of the volume of commerce, and with the hopes that we may legitimately entertain with regard to the future. The better distribution of the world's population in the world as a whole must make for the increase of production and of trade. The history of the world has known some remarkable changes in the mobility of populations. Looking back, we are often amazed at the courage of the races who migrated into the unknown without road or compass or map. After the irruption of the Turks, Europe seemed to reach a period of comparative settlement, in which men were largely content to stay in the place in which they were born. The end of the nineteenth century, however, renewed the process of resettlement in large masses which had been for so long interrupted, and a migration on a hitherto unheard-of scale came into being. We cannot give precisely the comparative facts for the various nations, but the accompanying figures compiled by the Board of Trade from th

official emigration returns of a number of important countries, will suffice to show upon how large a scale migration is proceeding from the Old World to the New.

There are no official emigration figures for Russia, but we know from the United States immigration returns that it receives as many as 90,000 Russians and Poles in a year. There are now, we see, several nations which are exporting their people to the New World at the rate of hundreds of thousands a year. For the most part, these people go from lands of restricted opportunity to lands of greater opportunity; they pass from a power of comparatively small production to a power of comparatively large production. Their standard of life often rises, and they become eaters of a superior diet and the consumers of larger quantities of goods.

There is another great reason why trade is so rapidly expanding, and it is no less a reason why it will continue rapidly to expand. It is a marked feature of the table of British trade which we give on the preceding page that the most recent years recorded in it show a much greater rate of expansion than that of any previous period. We may put it that there is a remarkable acceleration of expansion. There will doubtless be rhythms of trade in the future, as in the past; there will be good years and bad years. It is quite probable, however, that the acceleration will proceed, in view of the fact that we are becoming so much more daring in our use of the world. We are beginning to work on a much larger scale, and to realise that it is not more difficult to work on a great scale than on a small scale. A petty business may easily be as troublesome as a big business, and a big business need not necessarily be more troublesome than a petty business. The principles which guide a transaction in hundreds of thousands are exactly the same principles which guide a transaction counted in millions or tens of millions. Not many years ago, the man in the City who put through a business in hundreds of thousands was considered to have done a big thing. Today we regard millions with great equanimity, and a capital in six figures is by way of being a small affair. Enlargement of the scale of work has undoubtedly had a great deal to do with the swelling of the trade figures of the twentieth century, which are in such remarkable contrast with those of the nineteenth century.

A great part in the development of trade is being played in the world-wide movement in favour of the improvement of the social conditions of the masses of the people. A moment's thought will show that trade must necessarily be restricted while the conception prevails, and is put into practice, that the masses of the people of all nations must necessarily be very poor, and that the well-to-do must necessarily be no more than a veneer of the masses. If trade is to be great, it must be broad-based. A few customers, however rich, cannot make enormous markets, and the only possible basis of a healthy great trade is a widespread purchasing power. Those, therefore, who desire to see the trade of the world expand far beyond its present dimensions have everything to hope for in the universal and rapidly growing determination to secure a higher standard of living for the rank and file of industry.

The social movement which has become so marked in the twentieth century has been a factor in the enlargement of the scale of trade, and it does not need a very fervid imagination to conceive how enormous are the possibilities of further expansion as wages rise throughout the world. The demand of a man for food is soon satisfied, and the possibilities of expansion in trade in food products are very strictly limited.

TEN YEARS OF EMIGRATION FROM EUROPE TO THE NEW WORLD

	From United Kingdom.	From Germany	From Spain.	From Italy.	From Austria-Hungary.	From Sweden.	From Denmark.
1900	169,000	21,000	55,000	172,000	117,000	16,000	4,000
1901	172,000	21,000	49,000	289,000	137,000	20,000	5,000
1902	206,000	31,000	44,000	295,000	185,000	33,000	7,000
1903	260,000	35,000	49,000	292,000	222,000	36,000	8,000
1904	271,000	27,000	79,000	267,000	163,000	19,000	9,000
1905	262,000	27,000	118,000	459,000	249,000	21,000	8,000
1906	325,000	31,000	118,000	523,000	313,000	22,000	9,000
1907	396,000	31,000	—	428,000	386,000	20,000	8,000
1908	263,000	20,000	—	246,000	103,000	9,000	5,000
1909	289,000	25,000	—	406,000	258,000	19,000	7,000
1910	398,000	25,000	—	—	—	—	—

Man does not live by bread alone, however, and human desires are, for practical purposes, unlimited in the domain of manufactured products. For homes, and the adornment of homes, for clothing, for the social amenities of towns, for pleasure-houses of various kinds, for instruments of sport and play, for material for the pursuit of the arts—who shall put a limit to the possible demands of mankind? We have but to think how poorly the masses of even a reputedly wealthy country like the United Kingdom, or Germany, or France, or the United States are furnished with goods to gain some conception of the fact that the trade that exists today—even the trade of 1912, which is so much bigger than the trade of fifty years ago—will be counted a small matter in years not far removed.

The social impulses, therefore, which are such a marked feature of the twentieth century have a strictly economic justification. It is not merely "doing good" to the poor which results when scales of remuneration are raised. Better wages are not a sectional interest of society; they are in every country a national interest; and, viewing the world as a whole, they are the common interest of mankind.

If the teeming millions of Europe alone could be raised to the modest standard of expenditure which we associate with the possession of an income on the line of the United Kingdom income-tax exemption limit—viz., £160 a year—there would be a huge increase in the turnover of traders, and the channels of trade would be deepened and widened far beyond their present dimensions. The hard fact of the case is, however, that in 1912 the great mass of the workers of Europe earn less than one pound per week. It is well for trade that we are able to affirm, with a good deal of confidence, that we shall probably not be able to make that statement with truth in twenty or thirty years' time.

The considerations we have reviewed all point in the same direction. They are at once an explanation of the remarkable progress of the last twelve years, and a promise of even greater progress in the time to come. We are helped to see industry and commerce as things of infinite possibilities of expansion, and we can form a conception of international trade, not so much as a struggle in which some succeed and others fail, but as a thing of common service in which all alike may share, and in which all alike may gain, if in unequal measure. Indeed, it is in sober truth difficult to set bounds to the probable widening of the trade channels of the future. The beginning of the twenty-first century, it is not too much to say, may witness as comparatively great an advance upon the world-commerce of today as the trade of the present day exhibits when compared with, let us say, the volume of international transactions in the days of the Stuarts. In the course of these articles we have given not a few facts of a character which go to support these hopes. It is not only progress that we are witnessing, but an extraordinary acceleration of progress, and there is every indication that it will continue far beyond our lives.

THE DAY SCHOLARS, AND THEIR AGES, IN THE SCHOOLS OF ENGLAND AND WALES

Age.	Population at Age.	At School.		Not at School.	
		Total Day Scholars.	Per Cent.	Number.	Per Cent.
11	683,700	678,457	99·23	5,243	0·77
12	687,300	669,050	97·34	18,250	2·66
13	690,300	497,725	72·10	192,575	27·90
12 and 13	1,377,600	1,166,775	84·70	210,825	15·30
14	691,000	155,682	22·53	535,318	77·47
15	682,100	71,921	10·54	610,179	89·46
16	649,200	40,149	6·18	609,051	93·82
14, 15 and 16	2,022,300	267,752	13·24	1,754,548	86·76
17	664,900	23,130	3·48	641,770	96·52
18	653,500	12,670	1·94	640,830	98·06
19	664,200	6,279	0·95	657,921	99·05
20	657,300	5,208	0·79	652,092	99·21
17, 18, 19 and 20	2,639,900	47,287	1·79	2,592,613	98·21

Those nations, of course, will succeed best who have been best fitted by nature to succeed ; but apart from the natural factors which man can at best only partly control, no trading nation need despair because of the progress of another. Most obviously it would go hard with Britain if coal were dethroned—that we showed in an early chapter—but as long as the possession of coal means the possession of the most economic source of industrial power, Great Britain has every opportunity of retaining a great commerce.

Are We Doing What is Necessary to Train for Trade?

Alterations in trade currents will, of course, accompany modifications of trade routes, as will be better realised after the opening of the Panama Canal, but that is of the class of things as to which a man, if he disquiets himself, disquiets himself in vain. In general, cause for optimism remains. There is more than enough room in the world of work for all those who fit themselves to do that work.

And that brings us to a most important consideration. It is necessary to ask ourselves, Are we doing all that needs to be done with regard to the training of the new generation for the work of the future? Not only is the standard of life in the world rising, but the standard of education also. Rule of thumb is passing for ever in all occupations of life, and those who desire to keep a country abreast of modern developments must see to it that the primary raw material of nationhood—viz., the children of the nation—receive an adequate training. We give, on the last page, a table, based upon the report of a Special Committee appointed by the Board of Education, in 1909, to investigate the school attendances of boys and girls in England and Wales between the ages of 11 and 21 years.

The Ending of Education Where it Should Really Begin

The facts given show what a small proportion of English and Welsh boys and girls continue their education after thirteen years of age. At fourteen years of age, it will be seen, over 77 per cent. of the boys and girls have left school for ever ; at fifteen years of age, over 89 per cent. have left school. If the student of society is interested enough to obtain permission to go over any elementary school in England, and inquires, when he gets to the top form, how many of the boys and girls are over thirteen years of age, he will find that there are few indeed. Nearly all of them leave school at the earliest age which the law allows, in order to earn money to assist their parents. The figures in the table, it should be understood, include not only scholars at public elementary schools, but those at secondary schools, technical institutes, schools of art, reformatories, Poor Law schools, etc.

Now, the fact about the training of the young is that very little in the way of education in its proper sense can be accomplished in a child until it has reached the very age at which most of the children of the country leave school for ever. Just as the powers are developing, just as the child reaches an age when schooling begins to be of real value to it, it is turned out of the school by economic necessity, and set to work to earn a few shillings a week to help the family income. Thus the great mass of the people remain uneducated, and have to begin life without that wonderful inheritance of knowledge which should be by now the right of every child born in a civilised land.

The Bright Hopes that May Be Entertained for an Educated Country

We must not consent to regard as education the smattering of information which we confer upon the nation's children. We have to see to it that the child does not go forth to begin the serious work of the world until it has got some proper understanding of the world which it is to enter, and of the store of Nature-knowledge accumulated by the world's scientists.

When thus armed, the industrial population of the United Kingdom can afford to face the future with equanimity. The records of British commerce which have been faithfully set out in these pages in their broad outlines are something to be proud of. The stagnant people of 1750 have, in a century and a half, developed into a great and a powerful Empire in happy union with the daughter-nations which have grown in liberty over the seas. We have given grounds for believing that the British Isles may not only hope to continue to maintain their existing population, but that there is no reason why they should not aspire to be the home of a nation of a hundred millions of prosperous people, the head and front of an Empire containing as many more white men. It is equally true that much has been done, and that much remains to do. If ever we are tempted to despair at the slowness of apparent progress, we can always find fresh inspiration by calling to mind how much has been already achieved.

"IN THY RIGHT HAND CARRY GENTLE PEACE"

THE STATUE OF PEACE THAT FORMS PART OF THE MEMORIAL BY MR. HAMO THORNYCROFT, R.A., ERECTED AT DURBAN IN SOUTH AFRICA

SHALL WE BE ONE FAMILY?

The Progress of International Laws and Universally Accepted Understandings

IS THE PARLIAMENT OF MAN ONLY A DREAM?

MANKIND has made such sensational social advances in the last three hundred years, and particularly in the last fifty years, that it is not an act of temerity to forecast its future in the moral sphere. Rather would it be an act of blindness, or of cowardice, not to do so.

Two men looked out through prison bars;
The one saw mud, the other stars.

The moment anyone, looking ahead, feels in his heart the coming brotherhood of the human race, the men whose eyes turn naturally towards life's mud point to bloated armaments, continued wars, manifold occasions of strife, festering jealousies, sinister ambitions, and they ask, "What is the use of saying 'Peace, peace,' where there is no peace?" But while it may be admitted that those who see only the stars are partly blind, they come nearer a true vision than the hopeless downward gazers. At any rate, it is so if the recent story of man's friendliness, nation with nation, has the meaning it seems naturally to bear.

Three hundred years ago there was no common understanding between the separated peoples of the world. Today there is a great volume of international laws, of accepted agreements, not between State and State only, but between all States, as subscribers to a world-policy. Interests common to all are considered by all; the great concord is always growing, and, proportionately, is narrowing the fields of strife and of uncivilised human power. We should be dull indeed if, notwithstanding the wariness of our sensitive nationalism, we did not ask how internationalism is progressing, and likely to progress.

Poets have foreseen the "Parliament of men, the federation of the world." Is it only a dream? Or is it approaching by clearly discernible steps? Which is the truer—the poet's fervent faith or final wail?

There shall come a time when brotherhood shows stronger
Than the narrow bounds which now distract the world;
When the cannons roar and trumpets blare no longer,
And the ironclad rusts and battle-flags are furled;
When the bars of creed and speech and race, which sever,
Shall be fused in one humanity for ever.

Oh, glorious end! Oh, blessed consummation!
Oh, precious day, for which we wait and yearn!
Thou shalt come, and knit men nation unto nation.
But not for us, who watch today and burn;
Thou shalt come, but after what long years of trial,
Weary watchings, baffled longings, dull denial!

Looking broadly over the world's story, have the years been so "long" since men began to attempt to settle differences between nations on the basis of law? We must remember that international morality has only been gradually dawning on mankind through the mists of vicious custom. For many centuries nations sought to be not only independent in government, but self-subsistent and separate in all their organisations. They had few intimate trade relations, and all other nations were more or less suspect. Under statecraft they were the pawns played by the ambition or the resentment of kings. Not till quite modern times did a consciousness of human kinship and the reciprocal interests of the masses of the people in all countries appeal to the imagination of the general public of even the most advanced States. Indeed, it was not till the year 1625 that any serious attempt was made to lay down the principles on which nations should act towards each other. Then it was that

Grotius wrote his "Treatise on the Right of War and of Peace," a book which laid the foundation of all that has since been done in the realm of international law. It is said that the first Minister accredited by China to Great Britain remarked that the European Law of Nations seemed to be "a very young law," and in truth he was right. Though it deals with the greatest of subjects, it is in essence one of the youngest of the laws; and mankind has not yet sufficiently realised its origin and scope to do just honour to the great Dutchman, Grotius, who founded internationalism. The time will come when he will fill a niche in the part of the Temple of Fame reserved for the few choicest spirits of mankind.

The Great Dutch Jurist who First Planned International Law

It may not be out of place to mention here the leading facts of the life of the founder of international law. Huig van Groot, born at Delft, April 10, 1583, was such a schoolboy prodigy that he had left Leyden University in his sixteenth year, and was participating in an embassage to France. Before he was eighteen he was back at The Hague, practising as a lawyer. Barneveldt, the great Dutch patriot, and Grotius worked together, not only in public life, but were joined in support of the theological doctrines of Arminius against the stern Calvinism of the Low Countries.

For this they were tried and condemned. Barneveldt lost his head, but Grotius was sentenced to imprisonment for life. His escape was eventually planned and carried out by his wife, who packed him in the great box which usually carried away his numerous changes of books. In France, the country to which he escaped, Grotius was held in high honour, and in his later life served as Swedish ambassador at the French Court. Not only was he one of the most profoundly learned but most tolerant and enlightened men of an age when tolerance and true enlightenment were rare; and the work he did as a beginner in international jurisprudence has the fine distinction of never having been superseded.

The State of Choas from which the Proposals of Grotius Pointed the Way

Why Grotius set himself the task of discussing the basis of agreements between nation and nation he explains by saying, "I observed throughout the Christian world a licentiousness in regard to war which even barbarous nations ought to be ashamed of—a running to arms upon every frivolous occasion, or rather no occasions, which, being once taken up, there remained no longer any reverence for right, either divine or human, just as if from that time men were authorised and firmly resolved to commit all manner of crimes without restraint."

That was the state of international affairs in the sixteenth century, from which we have advanced during the last three hundred years only; and it is with that state of universal war and violence without restraint that comparison of the present times must be made before we begin to despair of a fuller reign of reason when nation is dealing with nation.

It is impossible to give here, even in faintest outline, an account of the growth of international law, private and public, since the days of Grotius. In private matters, affecting the affairs of the individual—as when a citizen of one country is travelling, or trading, or making contracts, or testimentary declarations, or acting fraudulently, or criminally, in a foreign country—very definite understandings have been arrived at in many cases, to secure the ends of justice, and to prevent any clashing of the laws of one nation with the laws of another; and these wise accommodations are constantly being extended for the common good government of lands that have much intercourse.

How Governments are Narrowing Constantly the Area of Quarrelsomeness

It is the same with the intercourse of nations in an organised state, as Governments, whether in peace or war. Conference after conference has assisted in laying down general principles of justice to which all the civilised nations subscribe, so that the unrestrained savagery on which Grotius commented is barely possible under stress of the fiercest war. To prevent friction, for example—we can only mention one or two points—the conditions under which territory can be acquired by any country are formally stated and universally accepted. Discovery, for instance, without beneficial use and occupation, gives no title. The position of ambassadors in foreign States is regulated by general agreement—an embassy being treated as a part of the country sending the ambassador who occupies it. If war breaks out, certain international rules are accepted as applying not only to neutrals but other rules to the combatants. The tendency of all these rules is towards creating more humane conditions, and the belligerents now feel that the eyes of the

civilised world are fixed upon them, with approval of chivalry and execration for any sign of ferocity.

That this tendency to form binding, because universally accepted, international rules, or understandings, that have the practical effect of laws, will continue and expand is suggested not only by the developing humanity of the nations, but by the enlargement of their interests. As was pointed out by Frederic Seebohm, over forty years ago, in a thoughtful essay on International Reform, the chief countries of the world are passing rapidly out of the self-existent State, and are becoming commercially interdependent. The business interests of each are the business interests of all. In 1871 Seebohm used as illustrations Great Britain, Holland, and Belgium, and showed how they were living not on themselves but on the whole world. To these are now added Germany, the United States, all the British Colonies, France, Italy, Russia, and Japan, and indeed every country that engages in trade to a considerable extent. The broadening of commercial interests, no doubt, has led to commercial jealousies, while the new rivalries in trade have been settling down; but far more substantial than these rivalries are the permanent conditions of peaceful trade which affect all nations alike, and are susceptible of business-like arrangements that facilitate all enterprise and damage none.

The Unfortunate Reversion Towards Making Each Country Self-Dependent

It is true there are some signs of a backwash in favour of national trade independence at a great sacrifice, instead of world-wide interdependence at a profit. The economic theory of producing food and goods where they can be produced under the most advantageous circumstances and exchanging them by trade is discarded in favour of trying to produce less of everything for oneself at any cost; but the common sense, undeniable facts of business are so much against the attempt that it can never make headway, and the countries that must prepare to be self-contained in case of war are restive under the uneconomical exertion and cost. Thus Russia, in order to ensure that she shall have the means of providing munitions of war at home, artificially forces up the price of iron and steel manufactures by taxes, to give her products a chance, and keep them in existence, but the cost is doubled, and even then the competing manufacturers of other countries carry off most of the trade, at large profits to themselves.

The system of each country manufacturing for itself, and living by itself, with a distrust of general exchange, is breaking down at every point; and greater competition everywhere, bringing freer trade, spreads the need for international understandings and co-operation. Finance is already cosmopolitan, and commerce is increasingly so. The genuine wants of mankind, operating daily, flooding all the channels of trade, have effects which cannot be counterbalanced by national jealousies in support of vague traditions.

Trade as the Great Cement Between the Many Sections of Mankind

However racial feelings may be fanned, business will percolate with its mollifying influence. Not a pig the fewer will be sold across the Austro-Servian frontier because of the clashing of national ambitions, and any arrangement for stimulating the trade would overwhelm all other public considerations. Trade is the most universal and the safest solder of modern nations, and the world has never known its like before.

It may be argued that the spectacle of partial federation, between States that form one empire, is an object-lesson in co-operation, and the possibility of overcoming the difficulties of diverse communities acting together for common ends. Germany has succeeded in reconciling the claims and jealousies of its almost innumerable component parts, and that is a triumph which is almost as great as the federation of the civilised world would be. Australia can fall into line as a Commonwealth. Canada has long been a Federal Dominion reconciling the most diverse racial claims.

The American Republic and the British Empire as Great Spectacles of Federation

The American Republic combines many States variously peopled, and by no means interested in the same problems, yet its cohesion has not been weakened even by an outburst of internal war. Then there is the marvellously multiform British Empire, that holds together firmly through bonds of sympathy, though it is a patchwork of States. All these modern instances show the practical possibility of vast bodies of men federating safely, with advantage, and satisfying human feeling by their federation. Then why cannot the same effects be seen in even larger aggregates, and finally in the whole world? What is now happening makes the suggestion natural rather than an impossibility, but for the accumulation of rivalries and jealousies between one

aggregation of States and another, fostered to some extent by short-sighted trade antagonisms, but still more by military incitements.

We see, then, that more and more the nations are coming together, in spite of their armaments and out-of-date reliance on barbaric force; that the idea of peaceful agreement under a system of international rules has been formulated by Grotius, and is being gradually developed by later jurists; that already a considerable body of morally binding law has been produced by various Conventions, and formally accepted by the nations; that trade, though involving some acute rivalries—which, however, never need be more unfriendly than the natural rivalries of the market—is weaving the world into a great co-operative unity, with a better understanding of each separate part; and that modern systems of cohesive government between territories inhabited under widely diverse conditions strongly suggest larger aggregations, federations, and agreements, till the management of the world may conceivably become a single great Trust, and wars be eliminated.

The Various Lines of Advance Towards a World-Wide Understanding

On what lines can advance be made towards the great day when all man's ingenuity will be directed towards a permanent mastery of the secrets of Nature, and none of it befrittered away in attempts to attain a temporary mastery over his fellow?

We suggest that the movement will keep a steady advance along the channels of arbitration, law, and understandings, and that Parliament for the world will remain a phrase for the poets, embodying a broad idea incapable of practice, except so far as Parliaments may decant their essence into a Council world-wide in its operations.

Parliaments are losing in dignity as they more and more act up to their name. They have become local parleyings on subjects that are almost entirely local. Even when questions of wider range, and indeed universal bearing, are happily brought forward for discussion and the settlement of principles, the demand is for talk, and ever more talk, until nothing would be done except talking were it not for the national mercy of the closure. If we think of the Parliament of men in the existing Parliamentary sense, on however concentrated a scale, the idea is doomed. Parliament retains a certain historical dignity as the institution that gave human liberty a preserved working ground, but it has allowed itself to be swallowed up by loquacity, babbling chiefly for party ends. It serves practical purposes locally, and hence is being continually localised; and it gives some preliminary and educative sifting to larger questions in sight of all the people. But when the scale of discussion becomes international, Parliament has been frankly abandoned as an instrument of government by all the nations.. Talk can play round a subject, but not govern. Its commonest object is to postpone decision.

We see the impossibility of extending the Parliamentary model in the impracticability of an Imperial British Parliament.

The Deposition of Parliaments by Their Over-Much Talk

When States from all the world confer, it is ripened experience and clarified wisdom that are in demand. The wider the area represented, the less churning by talk is required. The idea of a Council, on the other hand, is that it receives wisdom by precipitation. But a Parliament lives for talk, is staged for talk, with an eye on the public audience. The sooner we dissociate the peaceful government of the world from the debased currency of the Parliamentary method, the better for it. It will, of course, give Parliaments something more to talk about; and Parliaments will evolve the men who govern on the wider scale, but the Parliamentary model is devitalised. It has been strained beyond adaptability by talk.

Arbitration will doubtless remain an exceedingly useful device in the field of international controversy, as in trade and industry, but something more than arbitration is needed as a means for attaining universal concord. For arbitration, useful though it must prove at a certain stage in human difference, comes into operation usually at somewhat too late a stage. It aims at settling a difference which has already been declared. Sides have been taken. Antagonistic cases are stated. And awards follow that raise exultation or engender disappointment, or perhaps leave both combatants dissatisfied.

The True Place of Arbitration—a Device Held in Reserve

As a reserve device, arbitration is essential, but it would be better policy to lay down rules for mutual judgment without resort to arbitration. Is it not possible to amass such a body of international law as will prevent much of the need for arbitration? If rules for the conduct of war, can be agreed upon, surely regulations for not only preserving peace, but preventing many

disputes which become subjects for arbitration, might be drawn up and accepted?

The diversities of national resources, national needs, and national character are so great, and tradition and existing legal usages have such a deep-rooted hold, that any code of international laws which trenched on local privilege, or perhaps even local sentiment, would be doomed to failure, but there is ample room for great extensions of laws acceptable to all civilised peoples. That is suggested by the frequency of treaties between nation and nation. Many of the points of agreement defined in treaties could be embodied usefully in an international form, and their acceptance would then have a more binding moral power than if they were only an arrangement between individual nations.

The False Aims of the Alliances of the Past—Ambitious Combines

But probably the method by which amity between nations will be most rapidly and effectively approached is that of national understandings, or *ententes*. In the past, national alliances and friendly attachments have been arranged largely for the sake of preserving a changing figment known as the " balance of power," the kind of phrase which schemers adopt to " put off " those whom they are using and deluding. In these days of rapid national development, the relative native productive power of each nation is in a state of perpetual change. A quarter of a century may bring a new nation to the front, or finally prove the decrepitude of a historical empire.

These changes come through the action of forces which no combination of States can repress—the internal energies of an awakened people. The " balance of power " keeps shifting so precariously that its very existence is threatened. And, too, it is becoming clear that far more is to be gained by wide-spreading pacts of peace than from any combined preparation for possible war.

Why Should Not the Realities of Mutual Happiness Bring Universal Peace?

Indeed, it is difficult for the plain citizen to discern reasons why there should not be a coalescence of all *ententes* and a comprehensive League of Peace, within which each nation could seek its industrial and social destiny. Why should not Russia, the Colossus of Eastern Europe, be frankly neighbourly with Germany, the Colossus of Central Europe? Why should not the two greatest inter-trading nations of Europe—England and Germany—view each other's trading expansions with sincere congratulations, as being, in the end, profitable to both? The kingdom of human progress is international, save for rivalries that are wholly honourable and good, and that great instinctive concord may well and easily spread into the region of statesmanship.

What, then, are the prospects of some such agreement between the civilised nations as will abolish the arbitrament of war and inaugurate the reign of concord and national co-operation? It must be admitted that any plans are hopeless which assume a complete amalgamation with a forgetfulness of inbred and traditional characteristics. The evolution of differing nations has brought much human value into the world, and historic development and national tendencies must always receive ample allowance. Each nation will no doubt keep its own laws that fit its customs, but preservation of national identity should be no bar to amity and goodwill respecting all the essentials of civilised life. A peaceful understanding between all the civilised nations would not be one whit more complex than the internal agreement that binds together as one body of citizens the diverse inhabitants of the United States.

What Might Not the Coming of a Great Man Do?

If this understanding, this federation of independent States, is approved by reason, is demanded by humanity, and is vital to scientific economy, and if the forces of progress everywhere would be stimulated, and indeed exhilarated, by it, why is it not brought about? Only the leaden weight of custom and " Old Wont " stands in the way; and it seems as though the great need of the world today is a re-incarnation of Carlyle's irresistibly great man who could break the spell of hampering usage and help men to do what they know in their hearts should be done. What such a man has to do is to complete, by the fusing power of enthusiasm, what Grotius, in his dry, legal way, began in the region of law. In his day the world was a turmoil; there was little thought on a broad scale; and appeal to all men was slow and barely possible, but he founded a movement towards unity that has developed ever since on the lines he laid down. Under the changed conditions of today, when so much human helpfulness is cosmopolitan, and noble ideas may spread by a splendid contagion, who can deny the possibility of a peaceful union of mankind, provided the man arrives who is great enough to arrest the world's attention and mould its thought and impulse?

DAWN

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By G. F. WATTS, R.A.

EUGENICS AND THE FUTURE

Keeping Up the Type of Manhood the Only Hope for the Preservation and Expansion of Progress

THE TRUE CAUSE OF THE FALL OF EMPIRES

We wish here to survey the broad lessons of human history, looked at from the eugenic point of view, and then inquire as to the prospects of the future. As the path of a comet may be prophesied from the observation of its past positions in the sky, so the destiny of our species may be, perhaps, inferred from the great record of its past.

The tremendous generalisation which we seem entitled to make when we look at history from our new standpoint is that there are two wholly distinct though mutually reactive types or kinds of progress, which are invariably confounded, and have not yet been distinguished by any of the many writers, historians and others, who have dwelt upon the phenomena of the rise, decline, and fall of nations. In his Sidgwick Memorial Lecture, delivered at Cambridge in 1908, Mr. Arthur Balfour chose the subject of decadence, as to which his solution was simple enough. To the question, What were the causes of the fall of Rome? he replied, "I feel disposed to answer, Decadence." Throughout that lecture, in which he rejects many of the historians' explanations, and finds himself reduced to the helplessness of the reply we have quoted, Mr. Balfour shows no sign whatever of appreciating the existence and the distinction between two forms of progress, which we shall here call respectively traditional and racial progress. It is here submitted that the key to history is to be found in the recognition of this distinction, a distinction which biology makes so clear that with its aid historians may yet succeed in solving the problems they have hitherto left so obscure.

In the case of all species other than man, the only possible progress, with rare and doubtful exceptions, is a racial or inherent progress, dependent upon a choice or selection of parents, and comparable in some measure, as Darwin showed, with the change similarly produced in the selective breeding, or "artificial selection," of the lower animals by man. Unless Life, acting in subhuman species, produces forms of higher type, and those forms survive, leaving their like behind them, the race cannot progress. The only exception would be presented by, say, the case of the birds who teach their young how to fly, if we can suppose that flying lore could be gradually accumulated from age to age and handed down, so that the young birds of today would get better instruction from their parents than the parents got, and could add to this by their experience before teaching their offspring. Then there would be a kind of progress due to *tradition*, the handing on of acquired knowledge and capacity from generation to generation, quite apart from any inherent advance in the quality or capacity of the race. The more we learn of animals, and notably of the insects, the more cautious, perhaps, we become in denying this or that possibility to them; but the traditional passage of knowledge from one generation to another must be so extremely limited in all the animal species we know that it is practically non-existent, and there is nothing corresponding to it in the vegetable world.

But now observe the practically unique case of man, by whom there is attainable an obvious and effective form of progress which is not inherent or racial progress at all, but yet is real progress, and which has the most important relations to the inherent or racial progress that might be achieved by the survival and parenthood of the best in each generation. Elsewhere in POPULAR SCIENCE it has been shown that, once again to use a too brief phrase,

acquired characters are not transmitted by heredity. Thus, a man spends his life in the study of language. At forty years, when his acquired knowledge is immense, he becomes a father. But his son is born with no more knowledge of language than if his father had spent the life of a yokel. The son has to begin at the beginning, as the father had. Otherwise Natural Eugenics would be practically superfluous, for by a snowball process we could quickly advance the race, each child of a properly nurtured parent starting with a consequent natural advantage.

Nevertheless, and here is the great point, man has learnt, to his incalculable advantage, how to circumvent, as it were, the laws of heredity by transmitting his spiritual acquirements through language and art. If Socrates, more than two thousand years ago, said that "To the good man no evil thing can happen," or if Bruno, three centuries ago, declared that the stars are suns and the sun is a star, we of today can take and use such ideas. They are not lost, though Socrates and Bruno were both duly murdered by the men of their time, and though we are not their physiological descendants. This is what it is to be an "heir of all the ages."

The Stupendous Invention of Writing the Cause of Man's Amazing Advance

We enter into what Professor Mark Baldwin, the distinguished American psychologist, has taught us to call the "social heritage." It is the possibility and the existence of this social heritage that is the distinctive mark of the history of man, as compared with any other living species.

Even before writing there was tradition, passed on from mouth to mouth. "Man before speech," *homo alalus*, as he has been called, lacked the essential character of man. He could not transmit his spiritual acquirements by language. Until the human brain and vocal apparatus attained the powers necessary for speech, we cannot reckon man as man. But thereafter tradition and traditional progress became possible. It was limited by the powers of the human memory. Tradition by word of mouth can do much, but it evidently has serious limitations, and is open to many possibilities of error. But at last came the stupendous invention of writing, by means of which traditional knowledge could be handed on, without impairment, to any degree whatsoever. Thus, with speech and writing came a true "transmission of acquirements" in a new and special sense. It is this transmission of spiritual acquirements outside the germ-plasm and in defiance of its laws, that must explain the amazing advance of man in the last ten thousand years as compared with the almost speechless ages before them.

The famous writer William Godwin said, as we now see truly, that "Literature, taken in all its bearings, forms the grand line of demarcation between the human and the animal kingdoms." This traditional progress, which depends upon the permanent record and accumulation of intelligence in literature, is peculiar to man.

The Possibility of Racial Decay Accompanying an Increase of Traditional Knowledge

It is an utterly different thing, in nature, though often not in results, from inherent or racial or eugenic progress, an improvement in the natural quality of mankind, dependent upon the happy choice of parents. And it is surely evident, on a moment's consideration, that acquired or traditional progress is compatible with inherent decadence. To use Coleridge's image, a dwarf may see further than a giant if he sits on the giant's shoulders; yet he is only a dwarf, and the other is a giant. Any schoolboy of today knows far more than Aristotle, the most encyclopædic mind of antiquity, and that is true progress of a kind; but the schoolboy is a mere dwarf compared with Aristotle, and may belong to a race which is intellectually degenerate as compared with his. Such a case would illustrate inherent or racial decadence subsisting with acquired or traditional progress.

Now, while the accumulation of knowledge and art and thought from age to age is real progress, to which we self-satisfied moderns, who have done so little for ourselves, are incalculably indebted, yet evidently this traditional progress depends for its stability and persistence upon the quality of the race.

The Loss by a Degenerate Race of the Heritage from its Forefathers

If the race degenerates—through, say, the selection of the worst for parenthood—the time will come when its heritage is too much for it. The pearls of the ancestral art are now cast before swine, and are trampled on; statues, temples, books are destroyed or burnt or lost. It is not merely that the degenerate race is no longer able to rival and add to the achievements of its ancestors; it becomes even careless of them, so that they are lost.

Aristotle once argued that without it, but ments of man, as he saw thets maintenance in the great age of Atheogress—or, at achieved over and over agae. beginning, having been repepsent writer as if they had never been. Stions and ago Ruskin was enraged at a veruse they instance of what we are arguing. litional was once one of the greatest states when world; but the bride of the sea, whose from Wordsworth has commemorated in we immortal sonnet, came down in the scale of being. The Venetians ceased to do great things, and to add to the achievements which their predecessors had added

THE GREAT HALL AT THE SCHOOL OF ST. ROCCO, VENICE, WITH TINTORETTO'S MASTERPIECES

to the traditional progress of mankind. Worse than that, the superb pictures of Tintoretto, on the roof of the School of St. Rocco, "were hanging down in ragged fragments, mixed with lath and plaster, round the apertures made by the fall of three Austrian heavy shot." These pictures, in Ruskin's judgment, were "accurately the most precious articles of wealth in Europe, being the best existing productions of human industry." But the degenerate Venetians were content to put a few buckets on the floor to catch the rain, while the master's pictures were left to flutter "in moist rags from the roof they had adorned."

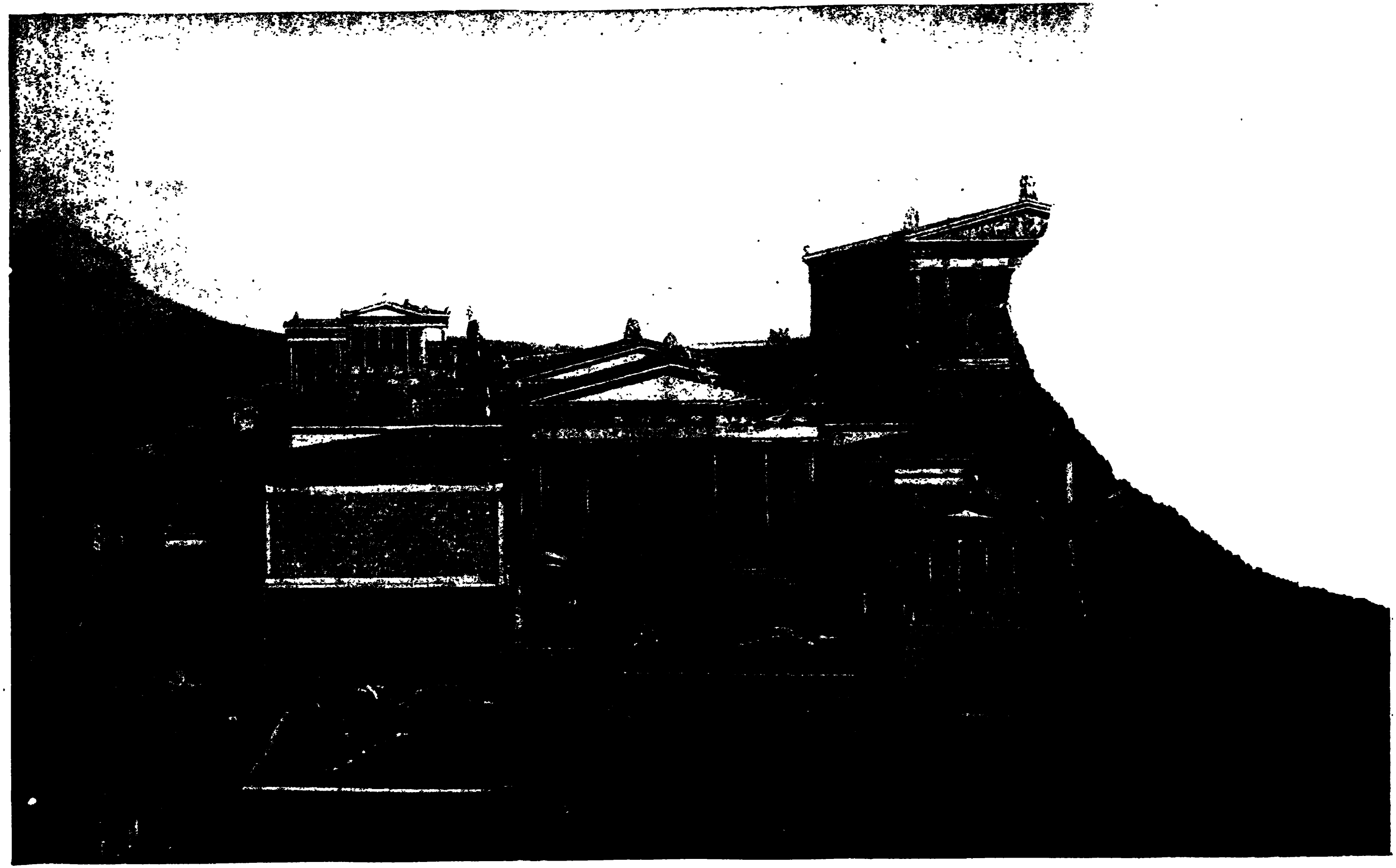
the Jews, have degenerated, but the oppressors, the triumphant, who seemed to have no foe left to fear? Why is it that nothing fails like success? Why do the names of all our Imperial predecessors, from Babylon to Spain, serve as a perpetual *memento mori* for us? Why was Byron right when he said—

There is the moral of all human tales;
'Tis but the same rehearsal of the past:
First Freedom and then Glory—when that fails,
Wealth, vice, corruption—barbarism at last.
And History, with all her volumes vast,
Hath but *one* page.

If the Fiji isl... there is little consequence ... no superstructure of accumulated learning and power is liable to fall; but if the breed of Romans degenerate all their vast mass of acquired progress and power crushes them into dramatic ruin.

From such an image we may perhaps infer the true relation between the two wholly distinct kinds of progress, which we have yet to learn to distinguish. Acquired or traditional progress will not compensate for racial or inherent decadence. If the race is going down, it will not compensate to add another colony to your empire. On the contrary, the bigger the empire, the stronger must be the race, the heavier the superstructure, the stronger the foundations. Traditional progress is real progress,

A SPLENDID CIVILISATION WHICH PERISHED THROUGH DECREP



ATHENS WHEN HER GLORIOUS ARCHITECTURE EXPRESSED THE ARTISTIC INSTINCT OF ANCIENT GREECE

and we should be nowhere without it, but it is always dependent for its maintenance upon racial or inherent progress—or, at least, upon racial maintenance.

On these grounds the present writer bases his belief that civilisations and empires have succumbed because they represented only acquired or traditional progress, which availed not at all when the races that built them up began, from whatever cause, to degenerate. Hence we have to conclude that the progress which matters fundamentally, and the decadence which matters fundamentally, are questions of racial quality, and that the key to history is therefore to be found in the causes which affect racial quality, for good or for evil. Mr. Balfour's view that the cause of decadence is decadence must be given substance by the interpretation that civilisations decline because the races that made them decline; and we must set ourselves to the discovery of the causes of racial degeneracy. We cannot accept the ancient and ever popular theory, advanced by notable writers from Plato to Mr. Balfour, that races, like individuals, must grow old and die. On the contrary, modern biology, and everything we have learnt from Weismann, from the study of the germ-plasm and from the records of life in the past, declare the capital fact which contrasts the individual and the race to be that, while the individual is doomed to die from inherent causes, the race is naturally immortal. The germ-plasm has no inherent tendency either to degenerate or to die, and biology knows many animal and vegetable species which exist and flourish now, and are millions of years older than mankind.


WORKERS WHO SHOULD BE AT SCHOOL

Some better theory of racial degeneration must be discovered, and it must be a theory which explains racial degeneration as history records it, among not the conquered, but the conquerors, among the successful, the Imperial, the cultured, the leisured, the well catered for in all respects, bodily and mental. Why is it that not enslaved and oppressed peoples, such as the Jews, have degenerated, but the oppressors, the triumphant, who seemed to have no foe left to fear? Why is it that nothing fails like success? Why do the names of all our Imperial predecessors, from Babylon to Spain, serve as a perpetual *memento mori* for us? Why was Byron right when he said—

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And History, with all her volumes vast,
Hath but *one* page.

The reason here maintained is that no race or species, vegetable or animal or human, can maintain—much less raise—its organic level unless its best be selected for parenthood. It is true of a race as of an individual that it must work for its living, so to speak, if it is not to degenerate. When the terms of life are too easy, down it goes.

The tapeworm is so successful that it has even found it possible to give up digesting for its living, and we know its degeneracy—all hooks and mouth. Society works and hands over its predigested food to such social parasites among ourselves. What if their numbers, thanks to Imperial supremacy, can indefinitely increase? Living creatures are in part the product of the struggle for existence. We are thus evolved strugglers by constitution; and directly we are so successful, having no more worlds, of matter or mind, to conquer, that we give up struggling, we must degenerate. "Thou, O God," said Leonardo da Vinci, "hast given all good things to man at the price of labour."

The case is the same with races. When the conditions become easy, the incompetent, the lazy, the vicious can be accommodated, and many are tempted to follow their lead. The race begins to suffer from fatty degeneration, and at last it dies of luxury, the mortal disease of Empires. Often its end is hastened by the phenomenon called *reversed selection*, when the worthiest leave no issue, and the race is maintained by the least worthy, when it is fitter to be

bad than good, cowardly than brave—as when religious persecution murders all who are true to themselves, and spares hypocrites and apostates; or when healthy children are killed in factories, while the feeble-minded are carefully tended until maturity, and are then sent into the world to reproduce their maladies. Under reversed selection such results are obtained as a breeder of racehorses or plants would obtain if he went to work on similar lines. The race degenerates rapidly, and if it be an Imperial race its empire comes crashing down about its ears.

When a primitive race is making its way by force, selection for parenthood is stringent. The weak, cowardly, diseased, stupid are expunged from generation to generation. As civilisation advances a higher ethical level is reached, all true civilisation tending to abrogate and ameliorate the primitive struggle for existence. The diseased and weakly and feeble-minded are no longer left to pay the penalty sternly exacted by Nature for their defects; they are rightly allowed to survive, but they are wrongly allowed to multiply. The distinction between the right to live and the right to become a parent is not recognised. A successful race can apparently afford to allow the defective to multiply, as a race that is fighting for its existence cannot, but in reality no race can afford this absolutely fatal process.

The Risk that Growing Industrial Progress May Hide the Fact of Racial Decay

There is thus a real risk involved in the accumulation of traditional progress. Not only does it tend, or has it hitherto tended, to abrogate or even reverse the selection of the best for parenthood, but it serves to disguise the consequences of that fatal process. If a subhuman race degenerates, the fact is evident; but such a nation as our own might quite possibly degenerate while the accumulation of acquired progress, transmitted by tradition, writing, education, almost completely cloaked the fact *for a time*. We might be congratulating ourselves upon our progress, upon our culture, our science and our art, our institutions, legal and charitable, while all the time the quality of the race was undergoing retrogression. The selection of the best for parenthood is the sole factor of efficient and permanent progress, but the traditional or acquired progress which we call civilisation has always tended to thwart or even reverse this process. Hence the conditions necessary for the *secure* ascent of any race, an ascent secured in its very blood, made stable in its very bone, have not yet been achieved in history; and this may be the reason why history records no enduring empire.

On this view there is nothing inevitable, no inherent necessity, in national decadence. It has causes which are controllable. And today it is possible to argue that we are in a new position, not paralleled by any of the great nations of the past. If our view of traditional progress be correct, the accumulation of knowledge must at last reach the point when man can understand the factors of his own history and destiny as never before. We are entitled to believe that modern biology, the science and the ideas which underlie eugenics, constitute a new and momentous stage in the age-long development of traditional progress.

The Causes of Decay Brought Now Within Man's Control

At last man knows so much that he can control his own destiny; at last he can begin to define, to identify, and even to control those causes of decadence which have sapped the power and the pride of all nations in the past. Perhaps the choice for us today is between National Eugenics and the fate of all our Imperial predecessors from Babylon to Spain; and perhaps today we can choose rightly, because, thanks to traditional progress, we know and understand as our predecessors could not.

The unique and remarkable case of the Jews appears to offer an illustration of the truth of the principles which we have just tried to lay down. The Jews offer no exception to the historical fact of the fall of empires. Their persistence may be the apparent exception which proves the rule that empires are mortal, for they have never had an empire, and they have thus never been subject to the risk involved for racial or inherent progress by the possession of great acquired or traditional accumulations of power.

The Unexampled Struggle of the Jews a Source of Their Unexampled Strength

It has been asserted that that race or people decays in which the selection of the best for parenthood ceases or is reversed; that in the absence of this process no species, vegetable, animal, or human, can prosper, much less progress. Now, the Jews, apparently the one human race of which we know that it has persisted unimpaired throughout the historic epoch, must have been the most continuously and stringently selected of all races that can be named. Every measure of

persecution and repression practised against them by the peoples among whom they have lived has directly tended towards the very end which those peoples least desired to compass. Other peoples found themselves prosperous through the efforts of their fathers; the struggle for existence abated; they died of luxury and empire. But this has never been the case of the Jews. They have always had to struggle for life intensely, and their unexampled struggle has been a great source of their unexampled strength. The Jew who was a weakling or a fool had no chance at all; and, the weaklings and the fools being weeded out, intensity and acuteness of mind became almost the common heritage of this amazing people.

The first principle of eugenics is that, to quote Ruskin, "There is no wealth but life." It is a practical religion of life. If it needs a motto or dogmatic definition to distinguish it from many imitations, let us say that *The products of progress are not mechanisms, but men.* This is no irreligious creed. It need not offend the followers of Him Who said, "I am come that ye might have life, and that ye might have it more abundantly." It honours men and women by declaring that human parenthood is crowned with responsibility to the unborn, and to all time coming.

Ruskin's Combination of Religion, Science, and Political Economy

It declares that man, the animal in body, is also a self-conscious being, "looking before and after," who is human because he is responsible, and to whom the laws of Nature have been revealed, not to satisfy an intellectual curiosity, but for the highest end conceivable—the elevation of his race.

The ideals of the majority in the nineteenth century have rightly passed into oblivion. They lived to coin money out of flesh and blood, and flesh and blood today despises and dismisses them. But there were a few who worshipped life rather than machinery even then; their ideas survive, and the mere knowledge which their century accumulated is now going to be used by the eugenic century, for the ends which they desired. Here is the famous passage, scorned at the time, which Ruskin wrote, combining religion and science and political economy in a single great statement:

"The final outcome and consummation of all wealth is in the producing as many as possible full-breathed, bright-eyed, and happy-hearted human creatures. Our modern wealth, I think, has rather a tendency the other way—most political economists appearing to consider multitudes of human creatures not conducive to wealth, or at least conducive to it only by remaining in a dim-eyed and narrow-chested state of being.

"Nevertheless, it is open, I repeat, to serious question, which I leave to the reader's pondering, whether, among national manufactures, that of Souls of a good quality may not at last turn out a quite leadingly lucrative one? Nay, in some far-away and yet undreamt-of hour, I can even imagine that England may cast all thoughts of possessive wealth back to the barbaric nations among whom they first arose; and that, while the sands of Indus and adamant of Golconda may yet stiffen the housings of the charger, and flash from the turban of the slave, she, as a Christian mother, may at last attain to the virtues and the treasures of a heathen one, and be able to lead forth her Sons, saying, These are MY Jewels!"

Can Deliberate Eugenics Ever be Expected to Breed Genius?

One great and final question may engage us. To reduce the number of feeble-minded, insane, epileptic, inebriate, is, of course, only a preliminary task of eugenics. The real problems will then remain. He would be a poor Eugenist who was satisfied with mediocrity, even though the sub-mediocre ceased to exist. But how much more may we reasonably expect to be able to do when, for instance, we have as much knowledge of the genetics of desirable qualities as we have already, in these early days, of the genetics of undesirable qualities? Sir Francis Galton's famous book of more than forty years ago, "Hereditary Genius," seemed to suggest that we might breed genius as we now most surely and freely breed mental deficiency and epilepsy.

Can We Not Rather Raise the Level of Mediocrity Than Raise Geniuses?

Can any such thing be expected? Not, at any rate, for a long time to come. But it would be something even to effect what Galton, in his later years, came to realise as more feasible. It would be something to raise the level of mediocrity. There would still be demagogues, no doubt, but, as he said, they would play "to a more sensible gallery than at present." If we could raise the average level of our population to that which may reasonably be asserted for the democracy of Athens in the age of Pericles, that in itself would be a tremendous achievement, yet not impossible, for what man has done man can do. No mere uniformity is to

be aimed at, or would be possible, fortunately. "It takes all sorts to make a world." "The aim of eugenics," said its founder, "is to represent each class or sect by its best specimens; that done, to leave them to work out their own civilisation in their own way." All except cranks would agree as to including health, energy, ability, manliness, and courteous disposition among qualities uniformly desirable, but added to these let us have the utmost conceivable variety.

And how far may we go? Better than any words of the writer's will be a statement of the belief of four illustrious and exceedingly different men, all writing in the nineteenth century, but from very various angles.

What Poets and Philosophers Think of the Range of Human Progress

First, Wordsworth, with his poet's questions, and then the student's answers—

And having thus discerned how dire a thing
Is worshipped in that idol proudly named
"The Wealth of Nations," where alone that wealth
Is lodged and how increased; and having gained
A more judicious knowledge of the worth
And dignity of individual man,
. . . I could not but inquire

. . . .

Why is this glorious creature to be found
One only in ten thousand? What one is,
Why may not millions be? What bars are thrown
By Nature in the way of such a hope?

Second, John Ruskin—

"There is, as yet, no ascertained limit to the nobleness of person and mind which the human creature may attain, by persevering observance of the laws of God respecting its birth and training."

Third, Herbert Spencer—

"What now characterises the exceptionally high may be expected eventually to characterise all. For that which the best human nature is capable of is within the reach of human nature at large."

Sir Francis Galton's Belief in the Evolution of the Superman

Fourth, Francis Galton—

"There is nothing either in the history of domestic animals or in that of evolution to make us doubt that a race of sane men may be formed, who shall be as much superior, mentally and morally, to the modern European as the modern European is to the lowest of the negro races.

"It is earnestly to be hoped that inquiries will be increasingly directed into historical facts, with the view of estimating the possible effects of reasonable political action in the future, in gradually raising the present miserably low standard of the human race to one in which the Utopias in the dreamland of philanthropists may become practical possibilities."

Faced with such names, perhaps the reader may surmise that the pessimism and cheap cynicism of some of the thinkerlings and professional jesters of today are not the deepest or highest wisdom, after all. Indeed, we are only beginning to see what the doctrine of organic evolution really meant. People began to tell the story, but they left out the point. Theologians were disgusted at the doctrine of man's animal ancestry, as if Deity were not the Author of every form of life. And they did not give themselves to consider what this doctrine implied for the future. For what inherent limits are there to the upward development of man as a moral and intellectual being? The greatest men and women of the past give us some indication, but not even they can give us all. One source of guidance alone we have in the amazing contrast which exists between the mind of man at its highest and mind in its humblest animal forms.

Why Should Not Man Travel as Far Forward as He Has Already Come?

The measureless height of the ascent thus indicated offers, as Tennyson saw and declared in several of his later poems, no warrant for the conclusion that, as we stand on the heights of our life, our "glimpse of a height that is higher" is only an hallucination. On the contrary.

We dare not say that the forces which have brought us thus far are exhausted; they have their origin in the inexhaustible. Who, gazing on the molten earth of ages ago, could have predicted life? Who, contemplating life at a much later stage, even later mammalian, could have seen in the simian the prophecy of man? Who, examining the earliest nervous ganglia, could have foreseen the human cerebrum? The fact that we can scarcely imagine anything higher than ourselves, that we make even our gods in our own image, offers no warrant for supposing that nothing higher will ever exist. What ape could have predicted man, what reptile the bird, what amœba the ant? Shakespeare said the truest word when he put into the mouth of a villain who knew himself to be a villain, and dared not deny the good, the prophecy, "There are many events in the womb of Time which will be delivered." And, with Browning's wise old thinker, we may add, "The best is yet to be."